UNIVERSITY *of the* WESTERN CAPE

Determinants for the acceptance and use of mobile health applications: Diabetic patients in the Western Cape, South Africa

Thesis submitted in fulfilment
of the requirements for the Doctorate in Information Systems
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by

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Degree of confidentiality:	None
Date:	11 December 2019

Declaration

Hereby I, Fazlyn Petersen, declare that "Determinants for the acceptance and use of mobile health applications: Diabetic patients in the Western Cape, South Africa" is my original work and that all sources have been accurately reported and acknowledged, and that this document has not previously, in its entirety or in part, been submitted at any university to obtain an academic qualification.

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Keywords

Sustainable Developmental Goals; National Development Plan 2030; diabetes self-management; m-health; critical realism; technology acceptance and use; information and communication technology for development; low and middle-income countries

Abstract

Introduction: The increased pervasiveness of information communication and technology and increasing internet access creates anticipation for how contemporary technologies can address critical developmental problems. Non-communicable diseases are the leading cause of death globally, even though more than 40% of the deaths are premature and avoidable. Diabetes is such a disease that causes 80% of non-communicable disease deaths in low and middle-income countries. Diabetes is also the leading cause of death in the Western Cape province of South Africa. Diabetes thus constitutes a challenge to achieve Sustainable Development Goal 3 that focuses on health and well-being for all people, at all ages. The potential of technology, such as the use of m-health applications, is recognised as a means to advance the Sustainable Development Goals through supporting health systems in all countries. This can be accomplished through improving the accessibility, quality and affordability of health services. However, despite the potential of digital technologies, the use of m-health applications remains low. Therefore, this thesis identifies determinants of acceptance and use of m-health applications for diabetes self-management in a geographical area where large segments of the population experience technological forms of exclusion in addition to educational and income inequalities.

Research design and methodology: This thesis is based on a critical realist paradigm. Critical realism includes three overlapping domains: the real, the actual and the empirical. The *domain of real* was analysed by examining structures, mechanisms and events evident in the Western Cape context, including the current level of diabetes self-management, the current level of access to, and the current use of technologies, such as mobile health (m-health) applications for diabetes self-management. Quantitative data was collected from 497 diabetic respondents living in the Western Cape. The *domain of actual* refers to events which can either be observed or unobserved, that are generated when mechanisms are activated. This domain identified challenges for the acceptance and use of m-health applications for diabetes self-management activities Qualitative data was collected from interviews with 131 respondents to identify challenges for the acceptance and use of m-health applications, given the present low m-health usage. Data were analysed using thematic content analysis.

In the *domain of empirical*, the findings which emerged from the literature and the domains of real and actual were synthesised into a multilevel framework of technology acceptance and use. An adaptation of a conventional acceptance and use framework was extended by including individual and higher-level contextual factors into a novel Multi-Level Framework of Technology Acceptance and Use extension that serves as a contribution to the body of knowledge. Quantitative data was collected from 514 diabetic respondents residing in the Western Cape. The research described herein used mixed methods, and the thesis argues that a combination of quantitative and qualitative methods improves the validity and leads to a greater understanding of a complex Information Systems and Health phenomenon. The research followed the ethical and professional guidelines as specified by the University of the Western Cape's research ethics policy.

Results: Findings from the domain of real indicate that diabetes self-management is low and that 67.4% of respondents do not use ICT such as m-health applications. Findings from the domain of actual indicate that effort expectancy, performance expectancy, social influence and facilitating conditions are potential challenges for the acceptance and use of mobile applications. Additionally, technology anxiety and a lack of self-efficacy are identified as possible reasons for the low usage.

Results from the domain of empirical indicate that four variables – performance expectancy, social influence, habit and self-efficacy – have a positive influence on behavioural intention (R^2=54.6%). Additionally, facilitating conditions and behavioural intention have a positive influence on use for diabetes self-management activities, excluding smoking cessation (R^2=20.1%). Interestingly, internet access does not display a moderating effect on the relationship between facilitating conditions, behavioural intention and use, likely due to the majority of respondents having access to the internet but not using it for diabetes self-management activities.

Future work: Despite testing twelve variables, explicitly including contextual factors, the power of the contributed extended model to predict usage was still low (R^2=20.1%). Therefore, it is recommended that an alternative approach such as positive deviance with user-centred designed be considered to improve the acceptance of m-health applications, especially for older patients in low resource settings, guided by the novel extension contributed by this thesis.

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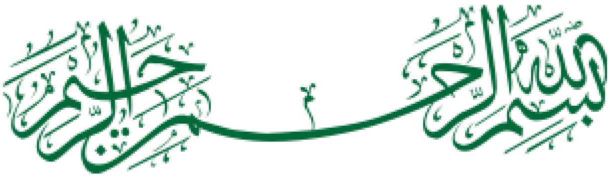
Acknowledgements and dedication



In the name of God, the Most Gracious, the Most Merciful for without my Creator I would not have been able to achieve any of this. My thesis could not have been completed without my parents, my husband, family and friends thank you for your support and understanding, especially when I have lost the plot many times. For my children who often had an absent, always working, always occupied with thinking about this thesis mother, this will soon end ☺

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Glossary of Acronyms

American Association of Diabetes Educators 7 (self-care behaviours)	AADE 7
Applications	Apps
Average Variance Extracted	AVE
Behavioural Intention	BI
Capabilities, Empowerment and Sustainability	CES
Centre for Diabetes and Endocrinology	CDE
Chronic Care Model	CCM
Community-Based Services	CBS
Continuous Glucose Monitor	CGM
Diabetes Mellitus	DM
Diabetes Self-Management Education and Training	DSME/T
Effort Expectancy	EE
E-health Enhanced CCM (see above)	eCCM
Electronic health	e-health
Electronic Journal of Information Systems in Developing Countries	EJISDC
Face-to-face	f2f
Facilitating conditions	FC
Hedonic Motivation	HM
ICT (see below) for Development	ICT4D
Ikamva National e-skills Institute	iNeSA
Information and Communication Technology	ICT
Information Systems	IS
Information Technology and International Development	ITID
Information Technology	IT
Innovation Diffusion Model	IDM
Innovative Care for Chronic Conditions Framework	ICCCF
International Diabetes Federation	IDF
International Telecommunications Union	ITU
Low and Middle Income Countries	LMICs

Mobile health	m-health
Multi-Level Framework of Technology Acceptance and Use	MultiTAU
National Department Of Health	NDOH
National Development Plan	NDP
Non Communicable Diseases	NCDs
Non-Insulin-Dependent Diabetes Mellitus	NIDDM
Partial Least Squares	PLS
Performance Expectancy	PE
Price Value	PV
Short Message Service	SMS
Social Influence	SI
Structured Equation Modelling	SEM
Summary of Diabetes Care Activities	SDCA
Sustainable Development Goal	SDG
Task-Technology Fit Theory	TTFT
Technology Acceptance Model	TAM
Technology Acceptance Model 2	TAM2
Theory of Planned Behaviour	TPB
Theory of Reasoned Action	TRA
Unified Theory of Acceptance and Use of Technology	UTAUT
United Nations	UN
University of the Western Cape	UWC
Unstructured Supplementary Service Data	USSD
User-Centred Design	UCD
World Summit on Information Society	WSIS

CHAPTER 1 - Introduction

I was diagnosed with type 1 diabetes at the age of seven. My brother was diagnosed at the age of twenty and my grandmother passed away due to diabetes complications. She was eighty-three years old so she had lived a longer life than most. She had diabetes for a long time but I don't recall following a healthy diet being very important in my family. I remember her making koeksisters (a deep-fried dough, dipped in sugary syrup and covered in coconut) on a Saturday and then I'd take these to neighbours. This was a big part of my granny's personality, our religion and the culture in Bokaap, where she lived for more than forty years. She wasn't going to change this way of life, the food she was eating and neither was she going to start exercising when she was diagnosed at sixty years old. Unfortunately, not following the doctor's advice resulted in her diagnosis of gangrene. She was told that her toes had to be amputated, but when we took her to Somerset hospital (she had no medical aid) for the surgery, she was informed that her leg had to be amputated instead. On the day of the surgery, she decided not to go through with it as she lived in a flat on the second floor in Bokaap, so how was she going to get up there? She passed away not long after…

1 Introduction

The World Summit on Information Society (WSIS) is a global United Nations (UN) multi-stakeholder platform that represents the world's largest Information and Communications Technologies (ICT) for the development community. Since the first WSIS convened in 2003, there has been much anticipation surrounding Information and Communications Technologies (ICTs) and ICT use regarding how the increasingly pervasive internet would address critical developmental problems (WSIS, 2014). However, even after the convening of WSIS +10 in 2014, it is clear that as governments prioritize the expansion of telecommunication infrastructure and an improved penetration of the internet, so too arises the need to assess whether or not this expansion results in development and improvements (WSIS, 2014). Therefore, the latest WSIS Forum facilitated the alignment of ICT with 17 Sustainable Development Goals (SDGs) (WSIS, 2019). SDG 3, in particular, focuses on the achievement of "healthy lives and the promotion of well-being for all at all ages" (United Nations, 2015a). The focus on health is similarly evident in the South African National Development Plan (NDP) 2030. The NDP recognises that consideration of the social and economic reasons that contribute to illness is an essential aspect of achieving health in South Africa (National Planning Commission, 2012).

This research assumes a health informatics perspective to understand the variables that influence the acceptance and use of mobile health (m-health) applications (apps) for diabetes self-management in a geographical region where its use is not yet pervasive. This chapter introduces the thesis: it presents the background to the research problem, argues the rationale for the study, and presents the research questions and objectives.

1.1 Context

Interventions that are supported by the use of Information Communication and Technology (ICT) are becoming more prevalent due to the low- and middle-income countries (LMIC) challenges and increases in the number of users on the African continent (ITU, 2017). International Telecommunications Union (ITU) statistics reveal that in 2018, there were 24.4% internet users in Africa as compared to 2.1% in 2005 (ITU, 2018). It is clear that on the African continent, the environment is becoming more enabling from a technology infrastructure perspective. However, the burning question which follows from this is: What effect is all this infrastructure expansion having on human development?

1.1.1 Human development and information and communication technology

Health, a key concept in terms of human development, is measured by the Human Development Index (HDI). Human development is based on three dimensions:

1. a long and healthy life – measured by life expectancy;
2. access to knowledge – measured by the average number of years of education received by people aged 25 years and older, in a life-time; and
3. a decent standard of living – measured by Gross National Income (GNI) per capita (UNDP, 2018).

South Africa's HDI value in 2017 increased by 13.1% from 1990 (UNDP, 2018). A contributing fact could be life expectancy at birth increasing from 62.1 years in 1990 to 63.4 years in 2017 (UNDP, 2018). South Africa, however, is positioned in the *medium* human developed category while ranking at a *low* level of 113 out of 189 countries (UNDP, 2018). There is an apparent opportunity to improve the HDI value further, an improvement which can be achieved by the incorporation of ICT. The envisioned benefits of ICT and development programmes include economic gains, increased innovation and human development (Intel Labs, 2010).

From a human development perspective, the application of ICTs within various spheres of health has gained much traction over the past two decades. Since the 1990s, there has been a continuously expanding body of literature in the area of health informatics (Friede, Blum & McDonald, 1995; Eysenbach & Jadad, 2001; Darkins *et al.*, 2008; Coiera, 2015; Wickramasinghe, N. Schaffer, 2018)

Health informatics can assist in achieving all three human development dimensions, including the strengthening of public health (Friede, Blum & McDonald, 1995), by improving access to health services and access to knowledge. The question regarding the impact of increased ICT on development has escalated on the international agenda of the United Nations (UN), the ITU and World Bank, amongst others (United Nations, 2000). In particular, attention has focused on how modern ICTs can enable the achievement of the Sustainable Development Goals (SDGs).

SDGs consists of 17 goals delineated as part of Resolution 70/1 of the United Nations General Assembly (United Nations, 2015b). SDGs aim to address global challenges such as poverty, inequality and health so that no one is excluded by 2030 (United Nations, 2015b). It is found that the SDG 3, focusing on the health and well-being of all, showed the highest level of correlation with ICT. Therefore, small investments in ICT are coupled with significant SDG gains, especially in countries such as South Africa (Huawei, 2018; World Health Organization, 2018).

However, from a health perspective, it has been determined that chronic diseases such as diabetes, for high risk and low-risk populations in South Africa, are not adequately managed in primary healthcare and tertiary care levels (Brand *et al.*, 2013). Therefore, the additional burden on the health care system in terms of overall mortality and morbidity (Guariguata et al., 2014) may force changes in the way that chronic conditions are being managed, especially in LMIC at primary health care and tertiary care levels.

Improving the quality of care for people with chronic conditions was included in the 'National objectives and indicators for chronic diseases' (Health Systems Trust, 2014). Its key indicator was 'Proportion of emergency admissions of persons with hypertension, diabetes and asthma', although no targets were set in 2003/2004 (Health Systems Trust, 2004).

Subsequently, the South Africa Strategic Plan for the Prevention and Control of Non-Communicable Diseases 2013-2017 included the following goal and target for 2020:

- *Goal:* increase the percentage of people controlled for hypertension, diabetes and asthma by 30% by 2020 in sentinel sites; and
- *Target:* a 25% relative reduction in overall mortality from cardiovascular diseases, cancer, diabetes or chronic respiratory diseases (Health Systems Trust, 2007).

In the area of health care, ICT can lead to more informed and activated patients which results, then, in better health outcomes, as this empowers patients to manage their health (Wagner *et al.*, 1996). The view of ICT as empowering individuals and communities is strongly linked to ICT for development (ICT4D) literature (Kleine, 2010; Heeks, 2010; Zheng *et al.*, 2015; Heffernan, Lin & Thomson, 2016; Walsham, 2017; Zheng *et al.*, 2018).

The use of ICT in health is often referred to as *electronic health* (e-health) of which *mobile health* (m-health) is a sub-segment (Department of Health, 2015). M-health refers to e-health applications that are accomplished with the help of mobile technology (Department of Health, 2015). The World Health Assembly recognises the potential of digital technologies to advance the SDGs through "supporting health systems in all countries in health promotion and disease prevention, and by improving the accessibility, quality and affordability of health services" (World Health Assembly, 2018:1). However, the potential of digital technologies to advance SDGs will only be realised if the necessary infrastructure to provide internet access exists.

According to Beratarrechea et al. (2014), despite a recent World Bank report that identified more than 500 mobile health pilot studies in LMICs, little evidence was found pertaining to the likely uptake, or best strategies, for engagement, efficacy or effectiveness. Therefore, based on the literature above, key observations deemed to be the most pertinent to this research are highlighted at the end of each section.

Key observation 1: The use of ICTs, such as m-health, can positively influence the three dimensions of human development and the achievement of SDGs by improving the acceptability, access and affordability of health services.

Key observation 2: Increase in infrastructure, such as access to the internet, is required to realise the potential of digital technologies.

Key observation 3: It is necessary to identify strategies for the uptake, engagement, efficacy and effectiveness of mobile health.

Key observation 4: It is argued that progressing the uptake and use of ICTs in areas such as health, requires consideration of factors that extend beyond supply.

1.1.2 South African policy space

Supply, in terms of infrastructure and access to ICT in the Western Cape, is governed by South Africa's National e-Strategy which encompasses seven key areas:

1. *Enabling policies:* South Africa's ICT and related policies should be forward-looking, transparent and predictable to enable inclusive growth and development.
2. *Infrastructure:* The digital society will be underpinned by the availability of infrastructure throughout the country. Interventions are thus needed to stimulate both the public and private sector investments building on SA Connect and the introduction of supply-side interventions to promote competition and SMME development in the telecommunications and broadcasting industries.
3. *Universal access:* all South Africans should have access to affordable user devices and high-quality services irrespective of geography and social status.
4. *Security:* Citizens should trust the ICT environment, knowing that their information and transactions are protected.
5. *Content:* South Africans should be involved in the development of local content taking advantage of the global nature of the ICT sector. There is a big scope for South Africa to emerge as one of the leading content industries on the continent and in the world. This must be supported by strong and affordable content rights management.
6. *Innovation:* Innovations should be geared toward growing the ICT sector while simultaneously introducing ICT enabled solutions in other key sectors of the economy. Government and society as a whole should focus on the development of

local intellectual property and knowledge to encourage local production and manufacturing.

7. *Skilling the nation:* A comprehensive skills development programme will create awareness and explain technologies to improve the uptake and usage of ICTs in societies (Department of Telecommunications and Postal Services: Republic of South Africa, 2017).

Skilling the nation has effectuated the implementation of a South African National e-Skills Plan of Action (NeSPA) 2012 with the aim of "Continuing e-Skilling the Nation for Equitable Prosperity and Global Competitiveness in the Knowledge Society" (Department: Communications, 2012).

Having universal service, access policies and an e-skills plan of action are important, but the focus must be on *how* people use ICTs, as well as including information about benefits and opportunities for people to learn (Alampay, 2006). This can enhance the empowerment of individuals and communities who would not otherwise have had these opportunities without access to ICTs (Kleine, 2010).

Despite the National e-Strategy considering infrastructure (Department of Telecommunications and Postal Services: Republic of South Africa, 2017), a strategy does not always translate into ecosystems, such as e-health, that are operationally effective. According to the South African Health Review 2013/2014 (Health Systems Trust, 2014), the Minister of Health published the National Health Normative Standards Framework for interoperability in e-health on 23 April 2014 (Government notice no. 314 of 2014, Government Gazette no. 37583, 23 April 2014). Despite the framework, there have been challenges in its implementation:

- "Widely differing levels of e-health maturity across and within provinces;
- Large number of disparate systems between which there is little or no interoperability and communication;
- Inequity of e-health services provided and expenditure on e-health across provincial and national departments of health;

- Expensive broadband connectivity;
- Absence of a national master patient index;
- Absence of a national unique identification system of patients; and
- Limited capacity within the public sector for implementation" (Motswaledi & Ramokgopa, 2012:10)

A study evaluating a framework for the sustainability of e-health systems in South Africa, considering three factors – social, environmental and economic – found that environmental factors are critical to the success of e-health sustainability. Additionally, the study notes significant differences in system environments between developing and developed countries, constituting further challenges to e-health success (Uluç & Çiğdem, 2016).

Given the targets for 2020 set by the South Africa Strategic Plan for the Prevention and Control of Non-Communicable Diseases (NCD) 2013-2017, the South African Health Review 2003/2004 has acknowledged the need to implement behavioural change interventions that address risk factors for chronic conditions. The risk factors for patients with diabetes include tobacco use, food consumption or diet (eating and related behaviours), physical inactivity and alcohol use. For diabetes, the associated behaviours were eating (Health Systems Trust, 2004) and physical inactivity (American Diabetes Association, 2014b). These risk factors can be minimised if ICTs empower patients to manage their conditions diligently.

Key observation 5: South Africa's National e-Strategy takes into consideration factors such as infrastructure and skilling the nation so that the uptake and usage of ICTs in society can be improved and expanded.

Key observation 6: Having universal service and access policies are essential, but the focus must be on *how* people use ICTs and whether or not this use leads to their empowerment.

Key observation 7: South Africa's National e-Strategy has not translated into ecosystems, such as e-health, that are operationally effective. Therefore, it is imperative to identify social, environmental and economic factors critical for the success of e-health sustainability within the environment where the technology will be implemented and used.

1.1.3 Empowering patients to manage their own health

Empowerment – based on the capabilities, empowerment and sustainability (CES) model – requires that individuals and communities have a minimum set of capabilities (Grunfeld, Hak & Pin, 2011) which are dependent on a specific type of ICT to gain access to and make effective use of ICTs (Grunfeld, Hak & Pin, 2011) and are linked to skilling the nation as part of South Africa's National e-Strategy.

Capabilities are also mentioned in the NDP – Vision 2030, *"At the core of this plan is a focus on capabilities; the capabilities of our people and our country and of creating opportunities for both"* (National Planning Commission, 2011). It is noted by the Ikamva National e-Skills Institute (iNeSI) that *"the lack of access to these technologies rapidly increases inequity, negatively impact on social cohesion, reduces effective health care outcomes, increases crime, and reduces life opportunities for the disadvantaged and those most in need"* (iNeSI, 2019).

Also linked to the CES virtual spiral model, NDP and South Africa's National e-Strategy, the sustainability for ICT projects are fundamental to realise benefits within communities. The realisation of community benefits can be achieved by embedding them within local social structures with minimum disruption to existing social structures (Breytenbach, De Villiers & Jordaan, 2013). However, while the achievement of health outcomes, through the use of ICT, may be dependent on it, the South African National e-Strategy does not explicitly refer to the concept of consideration of social structures,

The literature does, however, provide some insight concerning the centrality of social structures in relation to ICT adoption. For example, the choice framework (Kleine, 2010) which defines health and social resources as a part of an individual's "agency", which in turn affects how these individuals interact with "structures" (i.e. access to ICT), attempts to operationalise Amartya Sen's capability approach. Sen argues that development is linked to the freedom of choice in a personal, social, economic and political sphere. In South Africa, a country with a legacy of apartheid and significant inequalities (Leibbrandt *et al.*, 2012; Gillwald *et al.*, 2017)**,** these four spheres are essential for analysing the context for the use of ICTs for health.

It is evident that attributes of an individual citizen, or potential user, of an ICT application is a critical consideration. This emphasis on user attributes is supported by Friemel (2016) who contends that internet access is strongly correlated to socio-demographic factors such as income, education, age and gender. A 'digital divide' results from disparities in these factors: the *digital divide* refers to the gaps in digital technology that lead to social exclusion and the unequal distribution of resources and life chances (Friemel, 2016). As the digital divide is endemic for people older than 65, an age group linked to patients with Type 2 (non-insulin-dependent) diabetes (American Diabetes Association, 2019), this is referred to with its own name – the *grey divide* (Friemel, 2016). It is likely that people and elderly people more specifically, who do not have access to ICTs or the economic means to purchase data will naturally be less likely to use ICTs for health-related purposes. This suggests that people of low socioeconomic status, particularly the elderly, likely lack the capabilities and resources necessary to achieve optimal health functioning.

Sen defines *functionings* as things that an individual may value doing or being (Sen, 1999), such as being healthy. Alternatively, it could also be argued that people may not value engaging in activities, such as exercising and adhering to a healthy diet, that will lead to them more adequate healthier. Being healthy requires effort and resources – such as access to nutritious food, medication and health care facilities – that are not evenly available to all. Therefore, all patients are incapable of achieving desired health outcomes due to existing inequalities.

Capability refers to "alternative combinations of functionings that are feasible" for an individual to achieve (Sen, 1999). Capabilities may refer to the source of ICTs as well as the knowledge and experience to use it. Functionings is representative of outcomes (Kleine, 2010) which can be the actual use of ICTs (Alampay, 2006). In other words, *capabilities* refer to structures and mechanisms, while *functionings* refer to events in the critical realism paradigm.

"An event can be defined as a specific happening or action resulting from the enactment of one or more mechanisms" (Wynn & Williams, 2012:792). Defining events in the critical realist paradigm will analyse the use of ICT, such as m-health, for the management of diabetes. According to Alampay (2006), actual use is affected by individual differences such as age, income, gender, skills, education and location. This is supported by Venkatesh *et al.* (2003) who include age, gender and experience as variables in their Unified Theory of Acceptance and Use of Technology (UTAUT) model (see Figure 21).

ICT for development (ICT4D) and literature regarding adoption (uptake, acceptance and use) are prominent points of IS research. However, it is critical to assess, specifically, the juncture of ICT adoption on development. The use of ICTs to assist with non-communicable diseases (NCDs) is a necessary topic as ICT that is rejected and unused will likely hinder the achievement of developmental goals.

NCDs are the leading cause of death globally, even though more than 40% of the deaths are premature and avoidable (Zhao *et al.* 2016). According to the International Diabetes Federation (IDF), in Africa, an estimated 15.5 million people have diabetes mellitus (DM) with the highest percentage of undiagnosed people (69.2%) (IDF, 2018). The statistics for South Africa show similar trends. According to the IDF (2018), there were 1 826 100 cases of diabetes in South Africa in 2017. The national diabetes prevalence is estimated at 8.39% with diabetes-related deaths accounting for 68 977 cases. Diabetes was one of the leading cause of death in the Western Cape in 2016, accounting for 6.8% of all deaths (Statistics South Africa, 2016).

As diabetes is a progressive condition, suboptimal treatment can result in severe and life-threatening complications (American Diabetes Association, 2014). Diabetes affects disadvantaged populations more than those in higher-income countries (World Health Organization, 2016). Eighty per cent of diabetes deaths are in low and middle-income countries (LMIC) (World Health Organization, 2016), while in high-income countries, diabetes control is lower among racial or ethnic minorities and those with low socioeconomic status (Ruddock et al., 2016). In South Africa, the prevalence of diabetes is greater in low-income urban populations (Health Systems Trust, 2004). These factors – low income and heavy population – constitute a challenge to the achievement of the SDG 3 (United Nations, 2015a). The focus on health is also evident in the South African National Development Plan

(NDP) 2030 as the NDP recognises that deliberately acknowledging the social and economic factors contributing to illness is an essential requirement for managing the health of the South African nation (National Planning Commission, 2012).

According to the South African Health Review 2003/2004, evidence suggests that changing dietary habits and increasing exercise are vital for diminishing the associated risk factors for chronic conditions such as non-insulin-dependent diabetes mellitus (NIDDM) (Health Systems Trust, 2004; American Diabetes Association, 2019). Therefore, reducing the percentage of people who are obese and overweight by 10% and increasing the prevalence of physical activity (defined as 150 minutes of moderate-intensity physical activity per week, or equivalent) by 10% was also incorporated in the South Africa strategic plan for the prevention and control NCD 2013-2017 by 2020 (Health Systems Trust, 2004). The reduction of people who are overweight and an increase in physical activity is supported by the World Health Organization (World Health Organization, 2020).

The framework for patient-centred diabetes self-management education and training (DSME/T) and care, as well as the American Association of Diabetes Educators (AADE) 7 Self-Care Behaviours, as defined by AADE, also supports healthy eating and exercise. The seven self-care behaviours essential for successful and effective diabetes self-management are as follows: 1) healthy eating; 2) being active; 3) monitoring the illness; 4) taking prescribed medication; 5) problem-solving; 6) healthy coping; and 7) reducing the associated risks (American Association of Diabetes Educators, 1997; Moss-Barnwell et al., 2020).

Despite these recommendations, LMICs experience serious challenges in terms of providing care for the escalating number of diabetes patients. These challenges include limited financial resources, limited workforce, high population growth, high burden of disease and difficulties experienced in extending healthcare to hard-to-reach populations (de Jongh et al., in press). It is imperative for patients with DM to self-manage risk factors daily. As diabetes self-management allows for improved health and well-being, with less reliance on the already-limited medical staff, interventions must include the provision of ongoing patient self-management education (Greenwood et al., 2017). Interventions are critical to preventing acute complications and reducing the risk of long-term complications (American Diabetes

Association, 2014) as diabetes complications are potentially quite serious: microvascular complications; “retinopathy, nephropathy, neuropathy (sensory, including a history of foot lesions; autonomic, including sexual dysfunction and gastroparesis) and macrovascular complications; coronary heart disease, cerebrovascular disease, and peripheral arterial disease” (American Diabetes Association, 2015: S18).

The management of diabetes, in particular, is well-suited to the use of clinical information technology (IT) because its management is characterised by quantifiable outcomes such as HbA1c levels and process measures (Siminerio, 2010; American Diabetes Association, 2019). While the monitoring of diabetes self-management can be supported through ICT, it has been determined that adherence to self-management activities was often poor (Cole-Lewis *et al.*, 2015; Stephani, Opoku & Beran, 2018a).

According to the World Health Organization (WHO), benefits of m-health include “reducing premature mortality from non-communicable diseases” (World Health Organization, 2018:2). This includes using m-health to improve awareness about “non-communicable diseases risk factors (including tobacco use, alcohol use, unhealthy diet and lack of physical activity), improving disease diagnosis and tracking, as well as self-care and home care and overall management of chronic conditions (including diabetes, cardiovascular, cancers and respiratory diseases)” (World Health Organization, 2018:2).

Key observation 8: Empowerment requires that individuals and communities espouse a minimum set of capabilities. These capabilities to gain access to and make effective use of ICT, dependent on the type of ICT, are linked to skilling the nation as in South Africa's National e-Strategy.

Key observation 9: The South African National Development Plan (NDP) 2030 recognises that considering the social and economic factors contributing to illness is an essential aspect for elevating the health of South African people.

Key observation 10: Literature provides several insights concerning the centrality of social structures concerning ICT adoption through the choice framework (Kleine, 2010) which acknowledges health and social resources as integral to an individual's “agency” which in turn affects how these individuals interact with “structures” (i.e. access to ICT).

Key observation 11: Sen’s capability approach posits that development is linked to the freedom of choice in personal, social, economic and political spheres. I concur that these four spheres are essential for analysing the context for ICT use for health purposes, especially in South Africa, a country with a legacy of apartheid and significant inequalities.

Key observation 12: User attributes are another vital consideration when analysing the context of ICT use since internet access is strongly correlated to socio-demographic factors such as income, education, age and gender. Therefore, the realisation of health benefits from ICT within communities can be more successfully achieved by embedding them within local social structures with minimum disruption to existing social structures.

Key observation 13: The digital divide is more prevalent for people over 65, an age group linked to patients with Type 2 (non-insulin-dependent) diabetes. Diabetes is a NCD that affects disadvantaged populations more than higher-income countries, constituting yet another challenge to the achievement of the SDG 3. Literature indicates that people of low socioeconomic status may not have the capability to achieve optimal health functioning.

Key observation 14: Literature indicates that behavioural change interventions, using m-health, can reduce premature mortality from NCDs. However, research been conducted in predominantly developed countries, whereas there remains a significant need for research in developing countries replete with challenges for providing adequate care to the increasing number of diabetic patients.

1.1.4 South African mobile health landscape

M-health has been identified as a mechanism to implement behavioural change interventions and address several notable challenges in LMICs, such as limited financial resources, limited workforce, high population growth, high burden of disease and difficulties experienced in extending healthcare to hard-to-reach populations (de Jongh *et al.*, 2012). Research indicates that simple interventions like mobile phone applications (apps) can decrease NCD risk factors (Zhao *et al.*, 2016): "Apps appear to be an ideal platform to deliver both simple and effective interventions" (Zhao *et al.*, 2016:2), thereby reducing premature deaths.

Wilhide III *et al.* (2016) claim that mobile technology assists with chronic disease management, such as diabetes, at both the individual and population levels. This is due to its ability to deliver real-time interventions connected to a health care team that will achieve health outcomes (Wilhide III *et al.*, 2016). However, Wilhide III *et al.* (2016) also admit that evidence of mobile health effectiveness has been inconclusive.

This view was also provided by Miele, Eccher & Piras (2015) who, analysing 600 diabetes-related mobile health applications, found that apps generally have only one (54, 1%) or two functions (28, 2%), did not have data forwarding/communication functions (68, 9%) and did not offer an interface to a measurement device (95, 4%).

Furthermore, a study analysing 6520 medical apps, of which 227 were for DM self-management, found that "most medical mobile phone apps lack expert involvement and do not adhere to relevant medical evidence" (Subhi *et al.*, 2015:1). In the case of DM apps, adherence to as evidence base was measured on 'inclusion of behaviours' recommended by the American Association of Diabetes Educators (Subhi et al., 2015). Another study found that typical medical or fitness apps have a 90-day user retention rate of only 27% to 30%, and 50% of these apps are downloaded fewer than 500 times (Birnbaum et al., 2015).

Therefore, implementing a technology-driven intervention does *not* guarantee that it will deliver the required targets for 2020, as defined in the South Africa Strategic Plan for the Prevention and Control of Non-Communicable Diseases 2013-2017. This is because technology delivered interventions can improve health behaviours and clinical outcomes of persons with diabetes, *only if* end-users accept and employ these interventions (Nelson *et al.*, 2016).

Research into the acceptance and use of ICTs is an established area in Information Systems (IS) (Venkatesh, Thong & Xu, 2016), with models based on the common-sense premise that "one must first use a technology before one can achieve desired outcomes" (Venkatesh *et al.*, 2016:329). There are several competing models of technology acceptance and use – Theory of Reasoned Action (Fishbein & Ajzen, 1975); Theory of Planned Behaviour (Ajzen, 1991); Technology Acceptance Model (Davis, 1989); and the Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003) – which must be used to test whether or not m-health applications deliver positive health outcomes.

In June 2013, there were 101 m-Health services throughout South Africa, of which 83 were active. Out of these 83, only 18 services were led by mobile operators with only three services addressing diabetes (GSMA, 2013). Despite this information, there is no indication as to whether the users of the m-health services for diabetes live in the areas where the technological exclusions are prevalent.

However, the South African National Department of Health (NDOH) implemented a successful m-health initiative in 2014, MomConnect (Barron et al., 2018). MomConnect has reached more than 1.5 million pregnant women and thereafter been scaled to reach more than 95% of public health facilities (Barron et al., 2018). The initiative was supported by the Minister of Health, Dr Aaron Motsoaledi, as well as receiving high-level government buy-in (Peter et al., 2018). MomConnect uses Unstructured Supplementary Service Data (USSD) and Short Message Service (SMS) to "connect pregnant women to health services; to encourage pregnant women to attend antenatal clinics as early as possible, preferably before 20 weeks of pregnancy; and to enable these women to interact with the health system. To improve service delivery, the last includes providing feedback on the quality of care received" (Barron *et al.,* 2016:203). The service, free to all users, is independent of mobile device type (Barron et al., 2018).

The successes of the MomConnect initiative is that while it scaled rapidly, it was supported by government leadership, multi-stakeholder partnerships and generous donor funding (Peter et al., 2018). Open-source software and open standards drive this initiative (Peter et al., 2018). MomConnect has a helpdesk, staffed by a team of trained nurses, who answer questions sent by mothers via SMS (Barron et al., 2018). Helpdesk staff also reply via SMS unless the problem requires an urgent response, in which case a phone call is made to advise the mother to attend a health care facility (Barron et al., 2016).

Research regarding m-health for diabetes referred to a mobile application called SignSupport (Chininthorn et al., 2015). An extension for SignSupport, Health Knowledge Transfer System (HKTS), was designed specifically for diabetes care (Chininthorn *et al.,* 2016). The application assists the communication and interactions between deaf patients and each staff/health professional involved in the diabetes care process.

Another qualitative study reviewed the benefits and challenges of m-health in community-based services (CBS) in South Africa, finding that the South African health system had a weak ICT environment and limited implementation capacity. As a result, the potential benefits of m-health for CBS retained with immediate large-scale implementation remains uncertain (Leon, Schneider & Daviaud, 2012). Large-scale implementation would be required to meet the accelerating number of patients with diabetes. Other than MomConnect, though, there are few examples of successful health system implementations (Nundy et al., 2012).

Rotheram-Borus *et al.* (2012) tested the feasibility and acceptability of a mobile phone-based peer support intervention among women in resource-poor settings for self-managing their diabetes. The secondary goals were to evaluate the intervention's effectiveness to motivate diabetes-related health choices. However, as the population sampled only included twenty-two participants, the results may not be generalised.

The Centre for Diabetes and Endocrinology (CDE) Club app launched a South African diabetes app with features including the following:

- Participation promoted by setting life actions, daily goals and the completion of health-risk assessments. For a CDE Centre patient, weight, blood pressure, glucose and HbA1c values are also recorded (van Wyk, 2017).
- Reputable information is provided such as scientific-based articles (van Wyk, 2017); however, it does not account for tracking of carbohydrates (Pieterse, 2017).
- Gamification is included and provides rewards that are redeemable at no cost. Badges are accumulated by completing actions (e.g. reading articles, watching videos and achieving clinical targets). The badges lead to the reward of coupons for discounts on numerous bands van Wyk, 2017).

This CDE app (see Figure 1) contains more than the common features found in mobile apps such as the "ability to track blood glucose, HbA1c, medications, physical activity, and weight" (Veazie *et al.,* 2018:vii). It provides similar functionality to a multifunctional application developed and tested by Petersen and Hempler (2017) that supports self-management for patients with newly diagnosed type 2 diabetics in Denmark.

Petersen and Hempler (2017) reported that the application was useful as it guided patients through the healthcare system after diagnosis. The final application included “five major functions: an overview of diabetes activities after diagnosis, recording of health data, reflection games and goal setting, knowledge games and recording of psychological data such as sleep, fatigue, and well-being” (Petersen & Hempler, 2017:1).

Figure 1: South African CDE app
Source: van Wyk (2017)

However, by September 2019, this app was no longer available on the Google Play store, as indicated in Figure 2. The discontinuation of m-health applications is a barrier to continued use.

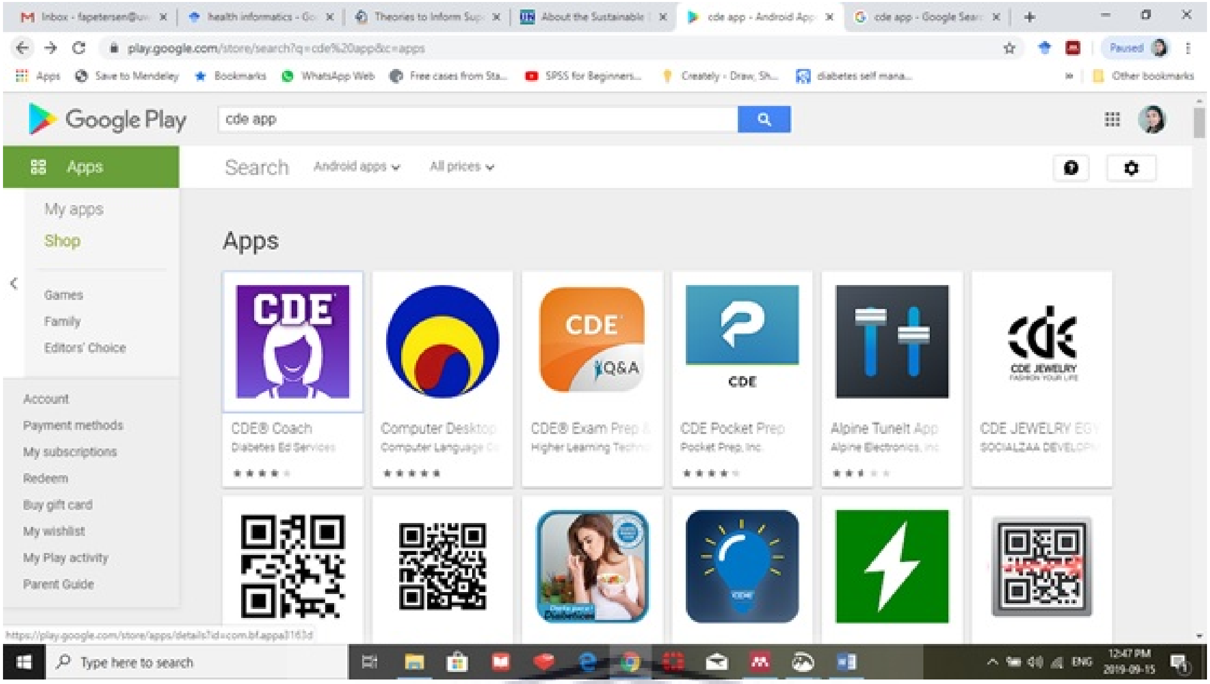


Figure 2: CDE app not available on Google Play store
Source: Google Play (2020)

Key observation 15: Mobile technology can assist with chronic disease management, such as diabetes, at both individual and population levels. However, evidence of mobile health effectiveness has been inconclusive.

Key observation 16: Typical medical or fitness apps have a low download rate and low user retention rate. Applications for diabetes were also shown to lack expert involvement and failed to adhere to relevant medical evidence.

Key observation 17: A technology-driven intervention is required to achieve the targets for 2020 in the South Africa Strategic Plan for the Prevention and Control of Non-Communicable Diseases, but this intervention will *only* be successful if end-users accept and use these interventions.

Key observation 18: In South Africa, a successful m-health initiative has reached more than 1.5 million pregnant women, with scale to reach more than 95% of public health facilities. However, there were only three mobile services addressing diabetes, with no evidence of diabetes m-health initiatives having been scaled. To the contrary, a South African diabetes app has been discontinued.

1.1.5 Western Cape context

The problem domain for the execution of this study was delineated to the Western Cape due to the increasing number of patients with diabetes and the fact that diabetes is the leading cause of mortality in this province (Statistics South Africa, 2016). According to the annual trends for diabetes incidence by province, 2013/14–2016/17, the Western Cape shows a rapid increase (Kengne & Sayed, 2017). In particular, the Overberg West has the highest average (1.4) of diabetes incidence per 1000 total population, followed by Cape Town (1.2) (Kengne & Sayed, 2017). Simultaneously, health care in South Africa has experienced severe staff shortages, especially in rural areas (Health Systems Trust, 2018). Therefore, alternative and more cost-effective options, such as ICT-facilitated disease management, are an urgent necessity.

The context in which patients with diabetes live and use ICT are critical factors to assess the impact on developmental goals (Hamel, 2010; Gigler, 2015). The Western Cape is one of the nine provinces in South Africa, "divided into one metropolitan municipality (City of Cape Town Metropolitan Municipality) and five district municipalities, which are further subdivided into 24 local municipalities" (The Local Government Handbook, 2017). The municipalities are delineated in Figure 3 below.

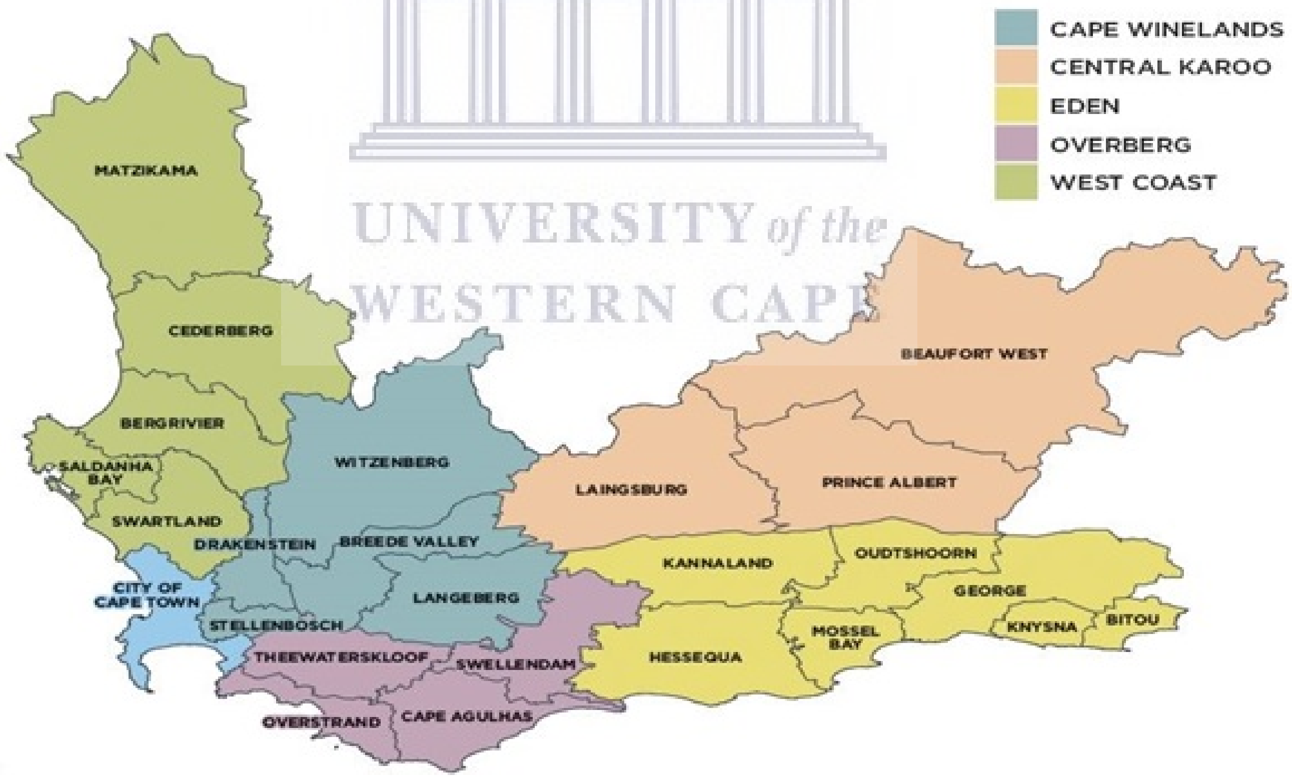


Figure 3: Western Cape municipalities
Source: The Local Government Handbook (2017)

The demographics of the province reflect the bleak socioeconomic plight of a substantive population. Moreover, the Western Cape has a history of racial segregation, officially implemented by the Group Areas Act in 1950 (South African History Online, 2011). The Act issued identity cards differentiating between five racial groups; Black, Coloured, Indian, Malay and White (South African History Online, 2011). Coloured people are typically mixed race, descendants of Malaysian slaves or Khoisan descendants (Mthembu, 2015). Under apartheid, 'non-white' groups were forcibly removed from areas in the City, such as District Six, and placed in outskirt township areas such as Khayelitsha and Mitchells Plain (Bähre, 2014). These areas are regarded as the Cape Flats (Bähre, 2014). Approximately 63% of households in the Khayelitsha and Mitchells Plain have incomes of less than R4166 per month (approximately $296), while 16.5% have no income whatsoever (Western Cape Government, 2017a).

The Western Cape reports a decline in the number of households connected to the main electricity supply, from 93.5% in 2008 to 87.9% in 2018 (Statistics South Africa, 2018a). Also, 19% of the Western Cape population live in informal dwellings (Statistics South Africa, 2018a). Informal dwellings frequently have limited or no access to water and electricity. This is despite the fact that "having adequate access to appropriate forms of energy is critical for improving living standards, health and reducing poverty" (Statistics South Africa, 2015).

The Western Cape includes large segments of the South African population who experience "technological forms of exclusion" as well as educational and income inequalities (Gillwald, Mothobi & Rademan, 2017:90). Despite the penetration of mobile phones (95.5%) into the Western Cape, only 25.8% had internet access at home (Statistics South Africa, 2018a). Therefore, the resulting digital divide between rich and poor is notable (Gillwald, Mothobi & Rademan, 2017), a divide which likely hinders the achievement of diabetes self-management as access to information is a key component in managing any chronic condition (Omisakin & Purity Ncama, 2011).

The Western Cape Government has recognised that broadband costs are still unaffordable to many citizens, so the Broadband Game Changer intends to provide *all* residents with access to affordable high-speed broadband infrastructure (Western Cape Government, 2017b). Also, the City of Cape Town is providing public Wi-Fi zones in more than 100 public buildings such as clinics, administration buildings and traffic departments across Cape Town. Moreover, Wi-Fi is currently available in several public spaces, such as the Company Gardens. Wi-Fi services are also being implemented at public transport interchanges such as Athlone, Atlantis, City Centre, Langa, Nyanga, Uitsig and Valhalla Park. Users are allowed 50MB per day and may purchase more data after that (City of Cape Town, 2018). This widening of accessibility provides a fertile ground for citizens, even from low socioeconomic demographics, to harness m-health apps for various personal uses, including that of diabetes self-management.

However, given the statistics in the Western Cape, it can be argued that socioeconomic conditions such as lack of internet access, low literacy and low-income levels in the province could heighten challenges in achieving developmental outcomes, including those in health. This is an important observation, given the high prevalence of diabetes in the province. Therefore, m-health interventions to achieve health outcomes must be carefully tailored to be effective, affordable and accessible to the Western Cape population, especially for groups with low socioeconomic status (Beratarrechea et al., 2014).

Key observation 18: The Western Cape has an increasing number of patients with diabetes and it is the leading cause of mortality in this province. The demographics of the province reflect that while the socioeconomic plight of a substantive population is bleak, there have been enhancements in terms of accessible internet provision to all residents.

Key observation 19: The Western Cape is comprised of large segments of the South African population who experience “technological forms of exclusion” as well as educational and income inequalities.

Key observation 20: The Western Cape socioeconomic conditions – lack of internet access, low literacy and low-income levels – could accentuate challenges in achieving developmental outcomes as these factors will likely impact the acceptance and use of m-health applications for diabetes self-management.

1.2 Problem statement

This research aimed to identify, study and understand the factors that influence the acceptance and use of m-health apps for diabetes self-management. The key observations listed in the preceding sections have been grouped to identify prominent areas that were explored by this research (see Table 1):

Table 1 Key observations to identify the areas for research

AREAS IDENTIFIED FROM THE LITERATURE	AREAS FOR RESEARCH	KEY OBSERVATIONS 
Human development	Understand the contextual factors that influence diabetes self-management	• The use of ICTs, such as m-health, can positively influence the three dimensions of human development and the achievement of SDGs by improving acceptability, access and affordability and health services. • The Western Cape has an increasing number of patients, and diabetes is the leading cause of mortality in this province. Demographics of the province reflect that while the socioeconomic plight of a substantive population is bleak, there have been improvements in providing internet access to all residents. • The South African National Development Plan (NDP) 2030 recognises that considering the social and economic factors that contribute to illness is an essential aspect of achieving the health of the South African nation. • Behavioural change interventions, using m-health, can reduce premature mortality from NCDs. • Research has been conducted in predominantly developed countries, whereas there is a greater need for research in developing countries with significant challenges in providing care for the increasing number of diabetic patients. • Sen's capability approach argues that development is linked to freedom of choice in a personal, social, economic and political sphere. I posit that these four spheres are essential to consider when assessing the context for the use of ICT for health purposes, especially in South Africa, a country with a legacy of apartheid and detrimental inequalities.
Empowerment	Identify social, environmental and economic factors that affect the use of m-health	• Universal service and access policies are essential, but the focus must be placed on how people use ICTs and whether or not this leads to their empowerment. • The benefits within communities can be achieved by embedding them within local social structures with minimum disruption to existing social structures. • South Africa's National e-Strategy did not translate into ecosystems, such as e-health, that are operationally effective. Therefore, it is vital to identify social, environmental and economic factors critical for e-health sustainability within the environment where technology will be implemented and used. • Empowerment requires that individuals and communities have a minimum set of capabilities. The capabilities are dependent on the type of ICT, to gain access to and make effective use of ICTs and are linked to skilling the nation as part of South Africa's National e-Strategy.

User attributes	Identify the challenges for m-health usage	• User attributes are another critical consideration when examining the context for ICT use. This is due to internet access being strongly correlated to socio-demographic factors such as income, education, age and gender. • The Western Cape includes large segments of the South African population who experience "technological forms of exclusion" as well as educational and income inequalities. • The Western Cape socioeconomic conditions, such as lack of internet access, low literacy and low-income levels could result in challenges in achieving developmental outcomes. These factors will likely impact the acceptance and use of m-health applications for diabetes self-management. • The digital divide is more prevalent for people older than 65, an age group linked to patients with Type 2 (non-insulin-dependent) diabetes. Diabetes is a NCD that affects disadvantaged populations more than higher-income countries, constituting a challenge to the achievement of the third SDG. Literature indicates that people of low socioeconomic status may not have the capability to achieve optimal health functioning.
Acceptance and Use	Understand how the use of m-health achieves developmental goals in developing countries	• Literature provides insight concerning the centrality of social structures concerning ICT adoption through the choice framework. • Increases in infrastructure, such as access to the internet, are required to realise the potential of digital technologies. • Universal service and access policies are essential, but the focus must be on how people use ICTs and whether or not this results in their empowerment. • There is a need to identify strategies for uptake, engagement, efficacy and effectiveness of mobile health. • Progressing the uptake and use, in areas such as health, must consider factors that extend beyond supply. • South Africa's National e-Strategy takes into consideration factors such as infrastructure and skilling the nation so the uptake and usage of ICTs in society can be improved. • Mobile technology can assist with chronic disease management, such as diabetes, at an individual and population level. However, evidence of mobile health effectiveness has been inconclusive. • Typical medical or fitness apps have a low download rate and a low user retention rate. Applications for diabetes were also shown to lack expert involvement and did not adhere to relevant medical evidence. • In South Africa, one successful m-health initiative that reached more than 1.5 million pregnant women has been scaled to extend to more than 95% of the public health facilities. However, there were only three mobile services addressing diabetes with no evidence of diabetes m-health initiatives that have been scaled. On the contrary, a South African diabetes app has been discontinued. • A technology-driven intervention is required to achieve the targets for 2020 in the South Africa Strategic Plan for the Prevention and Control of NCD, but this intervention will only be successful if end-users accept and use these interventions.

Table 1, non-communicable diseases (NCDs) are the leading cause of death globally, and diabetes was the leading cause of death in Western Cape. Diabetes control is lower among racial or ethnic minorities and those with low socioeconomic status. The demographics of the Western Cape reflect that the socioeconomic plight of a substantive population is bleak. Additionally, segments of the Western Cape population experience technological forms of exclusion as well as educational and income inequalities. The resulting digital divide is also significant. Additionally, despite the fact that several diabetes self-management mobile apps are freely available there are low levels of use. Therefore, there is a need to understand the determinants of diabetes self-management mobile apps use.

Research indicates that to improve the probability of m-health apps achieving developmental goals LMICs, such as South Africa, need to take into consideration country readiness (Majeed & Khan, 2019). This means that South Africa needs to consider their circumstances and resources (Khatun et al., 2016). This will allow for m-health apps to be adapted to country-specific needs (Hamel, 2010) where use in low socioeconomic areas is not pervasive yet (The Local Government Handbook, 2017).

1.3 Research objectives

Based on the research problem, this research seeks to identify the key factors affecting m-health application acceptance and to determine how this knowledge can be applied to generate more effective dissemination and acceptance for diabetic patients in the Western Cape, South Africa. This may increase the likelihood of achieving health outcomes made clear in the SDGs and other policies such as the NDP 2030.

Therefore, the specific research objectives are as follows:

- To assess the extant literature in respect to the role of m-health and ICT acceptance theories and models concerning developmental goals in health, especially in the case of diabetes self-management;
- To investigate:
  - contextual factors that influence diabetes self-management;
  - use of m-health apps for diabetes self-management to achieve developmental goals;
  - acceptance and use of m-health apps for diabetes self-management;

- To investigate the challenges for the acceptance and use of m-health apps for diabetes self-management; and
- To extend the extant theory of ICT adoption by developing a framework for technology acceptance and use in the realm of m-health apps for diabetes self-management.

1.4 Research questions

To achieve the aims and objectives, the following primary research questions were formulated:

i) What are the key determinants of acceptance and use of m-health apps for diabetes self-management?

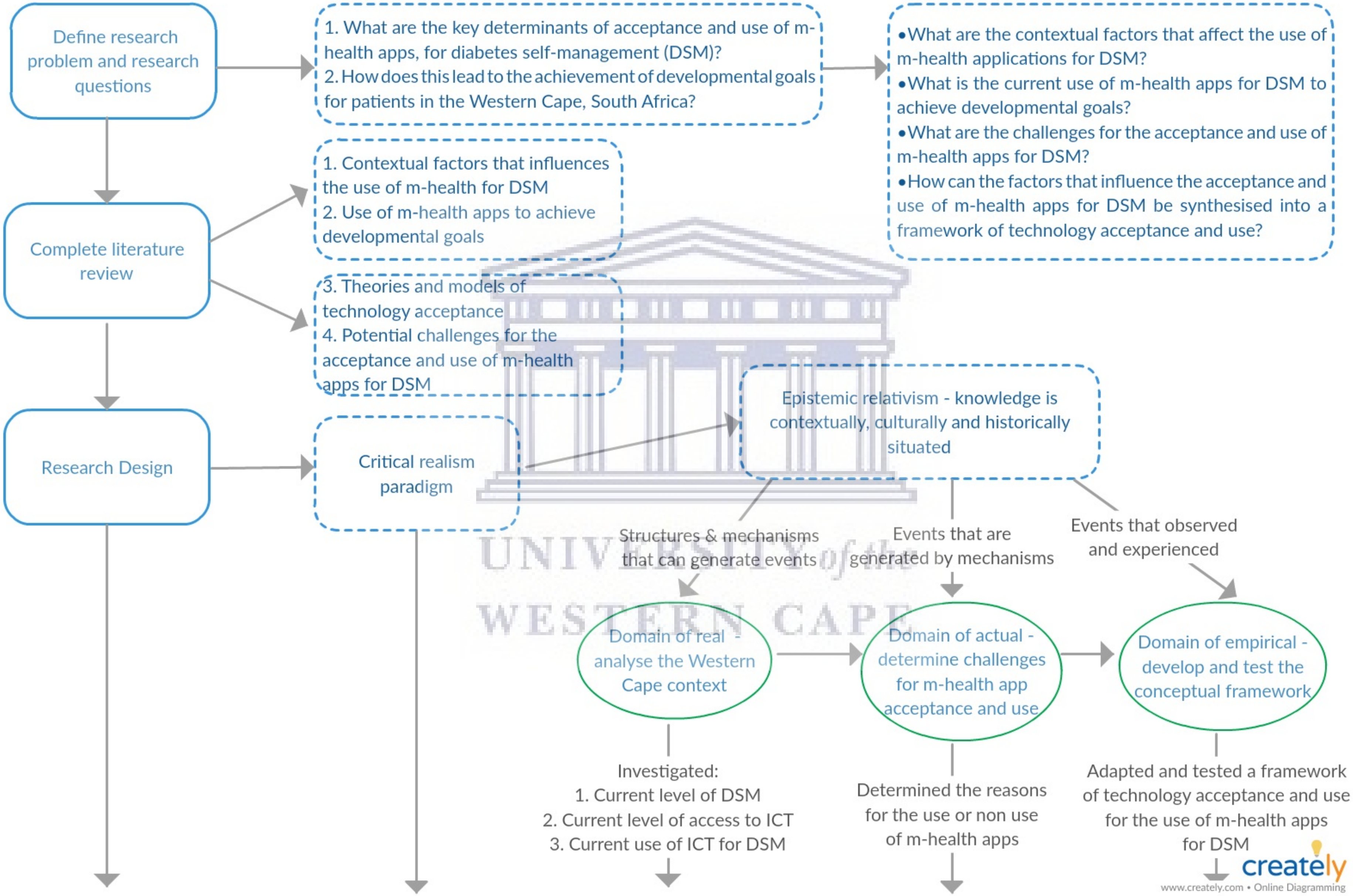
ii) How does this lead to the achievement of developmental goals for patients in the Western Cape, South Africa?

The following sub-questions will enable the research questions to be answered comprehensively:

- What are the contextual factors that affect the use of m-health applications for diabetes self-management?
- What is the current use of m-health apps for diabetes self-management in achieving developmental goals?
- What are the challenges for the acceptance and use of m-health apps for diabetes self-management?
- How can factors that influence the acceptance and use of m-health apps for diabetes self-management be synthesised into a framework of technology acceptance and use?

1.5 Research process

In order to answer the research questions and achieve the objectives of the research discussed in section 1.3, the following process was followed (see Figure 4):



Define research problem and research questions
1. What are the key determinants of acceptance and use of m-health apps, for diabetes self-management (DSM)?
2. How does this lead to the achievement of developmental goals for patients in the Western Cape, South Africa?
•What are the contextual factors that affect the use of m-health applications for DSM?
•What is the current use of m-health apps for DSM to achieve developmental goals?
•What are the challenges for the acceptance and use of m-health apps for DSM?
•How can the factors that influence the acceptance and use of m-health apps for DSM be synthesised into a framework of technology acceptance and use?
Complete literature review
1. Contextual factors that influences the use of m-health for DSM
2. Use of m-health apps to achieve developmental goals
3. Theories and models of technology acceptance
4. Potential challenges for the acceptance and use of m-health apps for DSM
Research Design
Critical realism paradigm
Epistemic relativism - knowledge is contextually, culturally and historically situated
Structures & mechanisms that can generate events
Events that are generated by mechanisms
Events that observed and experienced
Domain of real - analyse the Western Cape context
Domain of actual - determine challenges for m-health app acceptance and use
Domain of empirical - develop and test the conceptual framework
Investigated:
1. Current level of DSM
2. Current level of access to ICT
3. Current use of ICT for DSM
Determined the reasons for the use or non use of m-health apps
Adapted and tested a framework of technology acceptance and use for the use of m-health apps for DSM
creately
www.creately.com • Online Diagramming

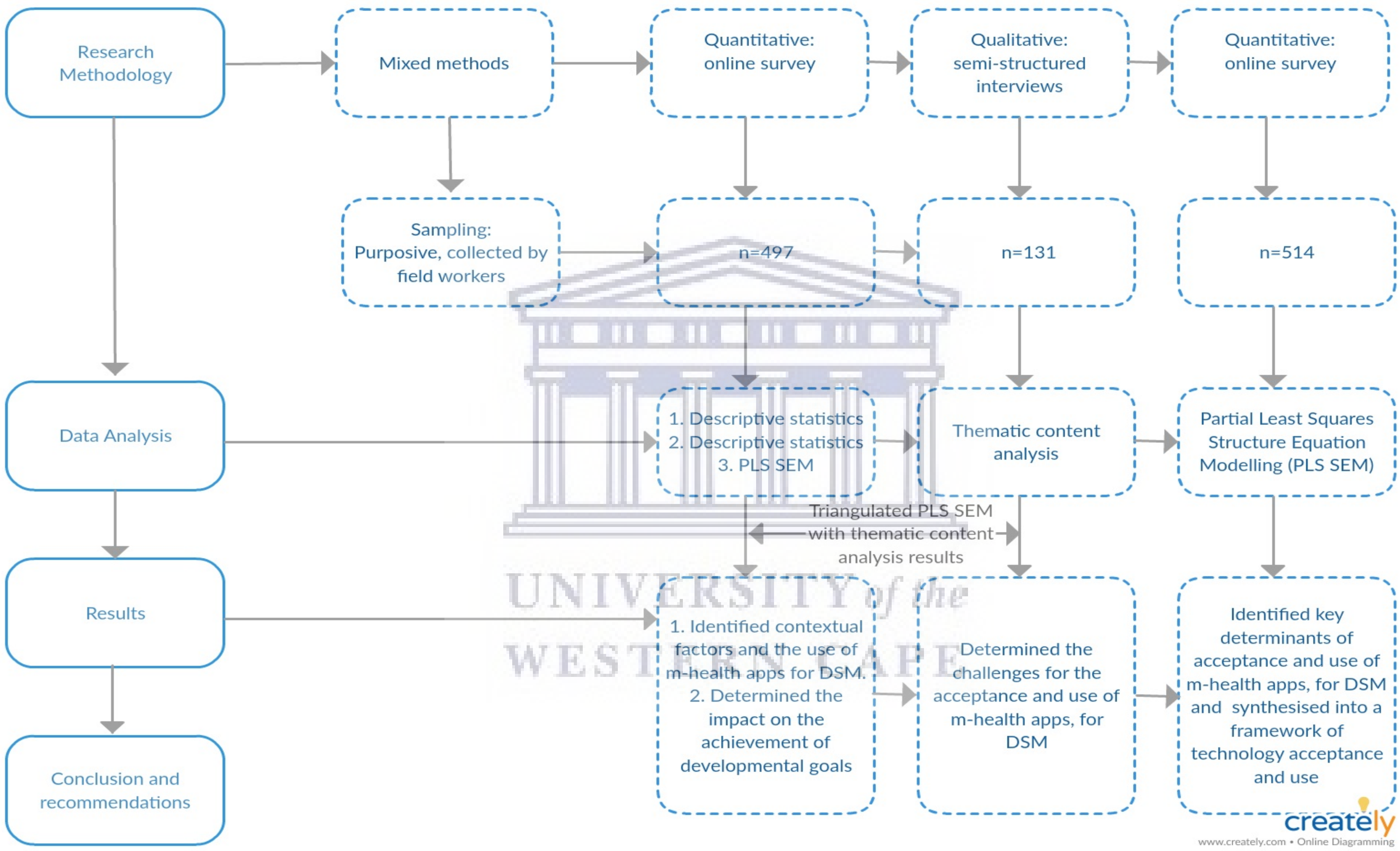


Figure 4 Research process

1.6 Significance of the research

The amount of literature for m-health interventions in developing countries is not as prolific as in developed countries (Vandelanotte et al., 2016). However, it is noted in reviews of other literature on m-health interventions in developing countries, that research primarily used text messages as part of the intervention (Free et al., 2013; Beratarrechea et al., 2017).

Therefore, the use of m-health apps shows promise in terms of achieving health outcomes, but this has been tested predominantly in patients in developed countries (Ariani, Koesoema & Soegijoko, 2017). In developing countries where the number of patients with diabetes is increasing rapidly, and the mortality rate is high, there is a need for interventions to address risk factors. However, achieving developmental goals by increasing the level of diabetes self-management, through the use of m-health apps, should take into consideration country-specific factors such as cultural beliefs, low income and education levels. This is dominant in diverse populations suffering from significant inequalities and technological forms of exclusion. It relates in particular to the notion of technology acceptance.

There is a gap in the current literature that examines the acceptance and use of ICT to achieve health outcomes for NCDs where the number of patients is increasing, but the use of m-health apps is not pervasive yet. Therefore, this area was examined in this research.

Therefore, this thesis contributes to the body of knowledge by examining the acceptance and use of m-health applications in achieving SDG 3, in the area of managing diabetes. This is due to the impact of the poor control of risk factors on morbidity and mortality on SDG 3 goals, especially in areas of low socioeconomic status (American Diabetes Association, 2015).

1.7 Publications resulting from the research

The following research outputs were created as part of this PhD thesis to obtain external reviews and make the knowledge generated available to a wider audience. The feedback obtained from reviewers was used to improve the quality of this thesis submission.

1.7.1 Journal article

Petersen, F.; Brown, A.; Pather, S. and Tucker, W.D. (2019). Challenges for the adoption of ICT for diabetes self-management in South Africa. *Electronic Journal of Information Systems in Developing Countries (EJISDC)*.

1.7.2 Conference proceedings papers

Petersen, F.; Baker, A.; Pather, S. and Tucker, W.D. 2020. Impact of socio-demographic factors on the acceptance of Information Communication and Technology (ICT) for diabetes self-care. In *Conference on e-Business, e-Services and e-Society* (pp. 73-83). Springer, Cham.

Petersen, F.; Jacobs, M. and Pather, S. 2020. Barriers for User Acceptance of Mobile Health Applications for Diabetic Patients: Applying the UTAUT Model. In *Conference on e-Business, e-Services and e-Society* (pp. 61-72). Springer, Cham.

Petersen, F.; Luckan, Z. and Pather, S. 2020. Impact of demographics on patients' acceptance of ICT for diabetes self-management: Applying the UTAUT model in low socio-economic areas. *2020 Conference on Information Communications Technology and Society (ICTAS)*.

Petersen, F.; Pather, S. and Tucker, W.D. 2018. A case for analysing user acceptance of ICT for diabetes self-management in the Western Cape, South Africa. Applying the UTAUT Model. *African Conference on Information Systems & Technology (ACIST) conference*.

Petersen, F.; Pather, S. and Tucker, W.D. 2017. A health informatics model for a user-centred design using a positive deviance approach: A case for diabetes self-management. *African Conference on Information Systems & Technology (ACIST) conference*.

1.7.3 Symposia

Jacobs, M.; Petersen, F. and Pather, S. 2019. The effect of culture on m-health acceptance of diabetes self-management in the Western Cape. *ID4A Postgraduate ICT4D symposium*.

Petersen, F.; Pather, S. and Tucker, W.D. 2019. Using Information Communication and Technology (ICT) to achieve developmental goals in low socio-economic communities: Diabetic patients in the Western Cape, South Africa. *South Africa Sweden University Forum (SASUF)*.

1.8 Layout of the thesis

The chapters and content of this thesis were structured as follows:

Chapter 2: Literature review

The literature review commences with the contextual factors that influence diabetes self-management, as this is essential for achieving developmental goals (World Health Organization, 2014). This is followed by the use of ICT to achieve diabetes self-management. Key theories and models for technology acceptance and use are inspected and critiqued. The literature study concludes with a review of the challenges for the use of m-health apps for diabetes self-management.

Chapter 3: Methodology

This chapter discusses research design and methodology with a focus on the three paradigms primarily used in IS research. To answer the research questions, a critical realist paradigm, with an epistemic relativism epistemology, was selected. The justification for the selection of the paradigm, ontology and methodology are highlighted. Critical realism uses three domains namely: the domain of real (quantitative), the domain of actual (qualitative) and the domain of empirical (quantitative). This study used a mixed-methods methodology. The findings are structured according to the three domains. It concludes with ethical considerations due to the nature of this research focusing on potentially sensitive health and contextual issues.

Chapter 4: Domain of real

The *domain of real,* referring to causal structures and mechanisms that generate events (Mingers, 2004), analyses the context in which patients with diabetes live within the Western Cape. Moreover, it determines structures such as the current level of self-management (impacting health outcomes), infrastructure to provide internet access (mechanisms) and the current acceptance and use of ICT, such as m-health, for diabetes self-management (events).

Chapter 5: Domain of actual

The *domain of actual* refers to events that are generated by the real that can be either observed or unobserved (Mingers, 2004). Based on literature and findings from the domain of real, this domain used qualitative analysis, employing semi-structured interviews to determine the challenges for acceptance and use for m-health applications. It concludes with a triangulation of findings from the domain of real and this domain.

Chapter 6: Domain of empirical

The results from the two domains as well as more recent literature were engaged to develop a conceptual framework to improve the acceptance and use of m-health for diabetes self-management for diabetic patients in the Western Cape.

Partial Least Squares (PLS) and Structured Equation Modelling (SEM) were used to test the conceptual framework for technology acceptance and use of m-health for diabetes self-management. The empirical data were interpreted in the context of the study, ensuring that the research objectives were met.

Chapter 7: Discussion and conclusion

This chapter, concluding the thesis, discusses the research in terms of the research problem, constructs development and empirical findings and closes with recommendations and points toward further study.

CHAPTER 2 – Literature Review

When I was diagnosed, my blood glucose level was higher than thirty, and it's supposed to be less than seven. I was admitted to Somerset hospital (we did not have medical aid) and stayed there for several days in the children's ward. I think that my mother cried more than I did, but I suppose that I did not realise that this was going to be the condition I'd have for the rest of my life. I remember the nurse demonstrating how I was supposed to give my injection. She even pricked herself to prove that it wouldn't hurt (LIES!). I practised injecting fruit then experimenting so that I had an apple that tasted like an orange ☺. I remember Sister Starke coming from Red Cross Hospital very late in the evening I was admitted because there wasn't another sister in the children's ward who could help me with my diabetes. I was grateful that someone would care so much to help me and she brought me children's books on diabetes (thank you, Sister Starke ☺). I think that the worst part for me was returning to school. I had to move from the A group and sit in the C group because I wasn't there to take the test (seats were allocated based on test scores). Now I had Type 1 diabetes and had to sit in the C group when I was an A group student! My mother told me not to tell anyone at school that I had diabetes because she feared that they would tease me; she was partially correct. So we told the teacher and gave her books and a glucose hypokit if I went into a coma. There were no other diabetics in the entire school; I was the first Type 1 diabetic pupil.

2 Literature review

This research aimed to answer the questions: *What are the key determinants of acceptance and use of m-health apps for diabetes self-management? How does this lead to the achievement of developmental goals for marginalised patients in the Western Cape, South Africa?*

The responses to these questions exist in the broad ICT4D field that has developed over the past thirty years (Walsham, 2017). The juncture between ICT and development in the area of health is referred to as *health informatics* (Friede *et al.*, 1995). Literature indicates particular issues need to be examined that move beyond merely increasing the supply of ICT (Heeks, 2010). For example, there is a need to understand the purpose and reasons for use, as well as how this leads to the achievement of positive developmental outcomes (Hamel, 2010). The concept of development, in terms of health, aims to empower patients to achieve their desired health outcomes.

Therefore, the literature review commences a critique of relevant ICT4D literature regarding health informatics and the contextual factors that influence diabetes self-management as this is imperative for achieving developmental goals (World Health Organization, 2014). This is followed by the use of ICT to achieve diabetes self-management. Prominent theories and models for technology acceptance and use are explored and critiqued. Finally, the literature study concludes with a review of the challenges for the use of m-health for diabetes self-management.

2.1 Information and communication technology for development

The role of ICT in development is a frequently debated issue, especially when the term '*development*' and the implementation of ICT in 'developing countries' are contested. It is argued that all countries are 'developing', as all countries must contend with issues such as health care, employment and education (Zheng et al., 2018). However, ICT4D should assist with the achievement of cultural, human, ecological and informational development (Heeks, 2016).

The emphasis for ICT4D is on delivery for the 'greater good' (Unwin, 2009). Achieving a greater good relates to SDG3, the achievement of healthy lives and the promotion of well-being for all, at all ages.

Despite South African developmental challenges (Turpin, 2018) in the area of health, education and unemployment, South Africa provides the ideal location to conduct ICT4D research (Turpin, 2018) due to the increasing implementation of infrastructure. This is evidenced by extensive South African research output in journals such as the *Electronic Journal of Information Systems in Developing Countries* (EJISDC) and *Information Technologies and International Development* (ITID) (Turpin, 2018). However, the history of ICT4D projects, even in South Africa, is not implemented without challenges.

Walsham (2017) divides the thirty-year history of ICT4D research into three distinct timeframes: early beginnings, expanding horizons and proliferation.

Table 2 presents the focus areas for each timeframe and a high-level application to the South African health system.

Table 2 ICT4D timeframes applied to the South African health system

TIMEFRAME	FOCUS	APPLICATION TO THE SOUTH AFRICAN HEALTH SYSTEM
1. Early beginnings (the mid-1980s to mid-1990s)	The focused was placed on IS and the social implications in developing countries. According to Walsham (2017), early beginnings focused on four themes: 1. "Context is important"; 2. "Participative and cooperative design"; 3. "The need for indigenous development"; and 4. "IT is only one element of change efforts" (p.20).	• The timeframe aligns to Heeks' (2008) view of the evolution from ICT4D 0.0, when "IT was viewed as a tool for delivering economic growth in the private sector" (p.26) while being ignored by development policymakers. • It is vital to consider that "cultural barriers to implementation present more difficult problems than technological issues because they provide the social context within which IS are interpreted and give meaning" (p.20). • The South African context during this period presented a legacy of apartheid with a fragmented and inequitable health system (Braa, Monteiro & Sahay, 2004). • The Health Information Systems Programme (HISP) started in 1994 at the University of the Western Cape (UWC), South Africa. UWC/HISP was involved in the national rollout of district health information software (DHIS) (Braa, Monteiro & Sahay, 2004).
2. Expanding horizons (the mid-1990s to mid-2000s)	Increases in the scope of ICT4D research due to the advancements in technology and the start of an interdisciplinary focus. The expanding horizons timeframe highlights the lack of ICT4D projects to deliver: 1. sustainability; 2. scalability; and 3. evaluation (Heeks, 2009).	• This timeframe relates to Heeks' (2008 and 2009) ICT4D 1.0 that had a supply-driven focus which regarded the marginalised as passive consumers. • HISP in South Africa, since 2000, has been commissioned by authorities for countrywide implementation; however, in Ethiopia and Tanzania, sustainability and scalability have had significant challenges (Braa, Monteiro & Sahay, 2004). • An ICT intervention to improve diabetes self-management will need to be sustainable and scalable or it will fail to serve the growing number of diabetic patients with daily management. A lack of evaluation will fail to determine whether an ICT intervention has been successful in achieving SDG and NDP objectives. Therefore, it is essential to identify critical success factors for ICT4D projects.

3. Proliferation (the mid-2000s to present)	Exponential increases in mobile technology as well as the need to understand the nature of development and the role of new technologies. The proliferation timeframe identified the critical success factors for ICT4D 2.0 projects: 1. Actors and governance: There is a need to include "multi-stakeholder partnerships and an open and competitive environment"; 2. Sustainable Projects: Financial and social sustainability, development of local capacities, use of local institutions and local ownership; and 3. Aligned and Contingent Design Techniques: participation of local users is required to identify the appropriate technology mix to align local realities with local development goals. Project risks need to be considered to prevent potential project failure (Heeks, 2009).	• The period relates to ICT4D 2.0 that focuses on the impact and uptake of ICT. The focus is on demand-side which regards the marginalised as active producers and innovators (Heeks, 2009). • South African has a complex m-health stakeholder framework with several distinct organisational groups (Department of Health, 2015). • In 2013, the Mxit platform was the most used service, reaching the highest number of mothers and expectant mothers (GSMA, 2013). • Maternity related mobile services, such as BabyInfo, had 760 000 users, while MomConnect had only 6100 users (GSMA, 2013). • "mHealth initiatives were led by non-governmental organisations (NGO) and funded by donors" (Barron *et al.,* 2018:1). This funding model may result in services that are not sustainable when donor funding has depleted. • The MomConnect initiative that uses open-source software and open standards scaled rapidly through the support of government leadership and multi-stakeholder partnerships (Peter *et al.,* 2018). A similar initiative is required for diabetes m-health interventions.

Additionally, Heeks' (2007) three main critiques for ICT4D research include the following:

1. Research is focused on action rather than the creation of knowledge;
2. ICT4D research is descriptive rather than analytical; and
3. Findings can lack credibility due to the lack of rigour.

An alternate view of ICT4D admits a disconnect between PhD research in academia, real-world issues and the people who could use the findings (Harris, 2016). ICT4D emphasises members of society at a lower socioeconomic status and the contribution of ICT toward their development (Walsham, 2017). However, it is questioned whether ICT4D truly benefits the poor due to the increasing specialisation and its quantitative nature, making it less accessible to the very public it is intended to serve (Harris, 2016). There is a clear need to disseminate knowledge to the masses through tools such as social media.

The real-world issue in this research focuses on the growing number of patients with diabetes and the need to deliver quality health care to these patients. ICT4D applies to this research as the acceptance and use of technology is an established IS field. This research seeks to examine the acceptance and use of m-health applications in achieving health outcomes for an increasing diabetes population where ICT usage is not significantly pervasive. As stated previously, development in the context of this research refers to human development, with the focus on empowering patients with diabetes to live healthier lives.

Empowerment is defined as "enhancing an individual's or group's capacity to make effective choices and translate these choices into desired actions and outcomes" (Alsop & Heinsohn, 2005:5). Empowerment and capabilities are linked to Amartya Sen's capability approach (see **Figure 5**) which is frequently adopted in ICT4D analysis (Walsham, 2017; Zheng et al., 2018).

As stated previously, the capability approach includes two core concepts: capability and functioning. "A functioning is an achievement, whereas a capability is the ability to achieve" (Sen, 1987:36). Interpersonal differences can affect an individual's ability to convert the same resources into valuable functionings ('beings' and 'doings'). For example, individuals in rural areas who live far from medical facilities could develop diabetes but suffer a lack of diagnosis or the provision of the necessary medication.

The social environment, in which patients live, such as living on the Cape Flats, an area prone to gangsterism, may not provide a safe space in which to exercise. This risky social environment thereby impacts the capability of achieving a core self-management activity. The lack of exercise will result in lower health functioning as exercise is integral to managing weight and blood glucose levels, thereby negatively affecting the patient's subjective well-being (utility).

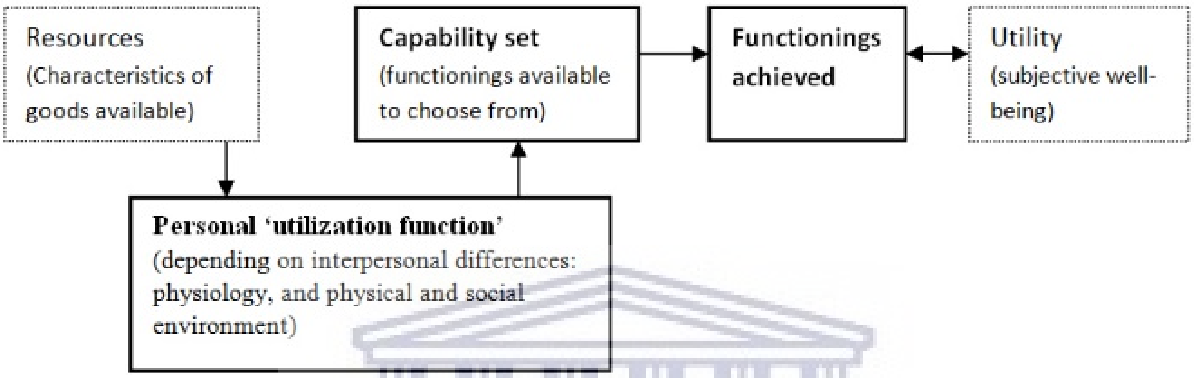


Figure 5: Capability approach
Source: Sen (1999:70)

It is recognised that the capability approach can contribute to understanding the impact on development, but there is no agreed-upon manner to apply it practically in ICT4D (Tshivhase, Turpin & Matthee, 2016). Consequently, the three models discussed below attempt to operationalise Sen's capability approach and incorporate ICT to achieve developmental goals.

Hatakka and De's capability approach framework (2011) incorporates the role of technology (the use of artefacts and features) into the delivery of supportive functions (use for training and support). The framework pinpoints the difference between potential and achieved functionings (see **Figure 6**): "An intervention can enable a potential functioning but conversion factors may hinder the choices of the people to utilize it" (Hatakka & De, 2011:6). Based on Sen (1992), three factors – namely personal (e.g. gender, literacy); social (e.g. laws, public policies); and environmental (e.g. infrastructure, resources) – are responsible for the conversion of a potential functioning into a realised capability. These factors relate to the personal utilisation function in Sen's capability approach (see Figure 5).

The model can be applied to this research area as follows:

- The introduction of a diabetes self-management m-health app with functionality to achieve self-management activities (e.g. diet and exercise tracking, the ability to upload blood glucose readings) will enable a potential functioning (i.e. to be healthier).
- However, patient ability to convert the potential functioning into an achieved functioning may be restricted by personal choices (or lack thereof).
- For example, patients may live in an environment rendered unsafe for exercise, or their purchasing of healthy food may be restricted by survival on a meagre government social grant.
- Therefore, *choice* is an essential component in the capability approach.

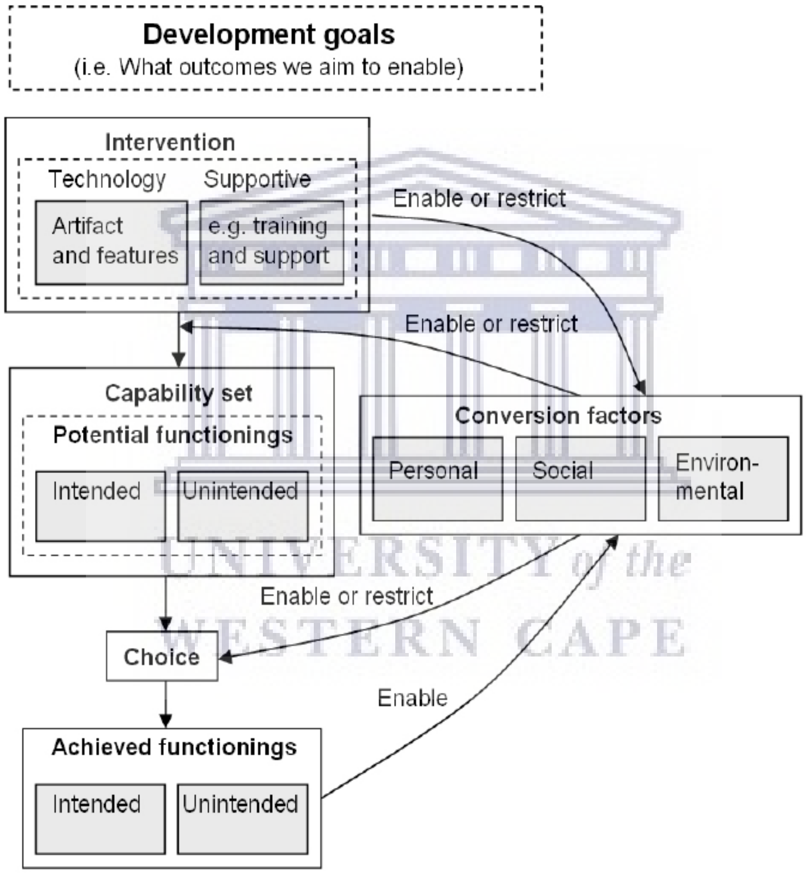


Figure 6: Capability approach framework
Source: Hatakka & De (2011:4)

In the choice framework (see Figure 7), the principal outcome is based on having a choice; empowerment is based on the dimensions of choice (Kleine 2010). When applying the choice framework to this research, the resource-based agency such as health (whether educational, financial, cultural, social or psychological) may be related to variables to investigate given the relationship to structure (Kleine, 2010). *Structure* includes access to ICT as well as the necessary skills to utilise these to derive the secondary developmental outcomes of improved health outcomes, health literacy and interaction with the health team for patients with diabetes.

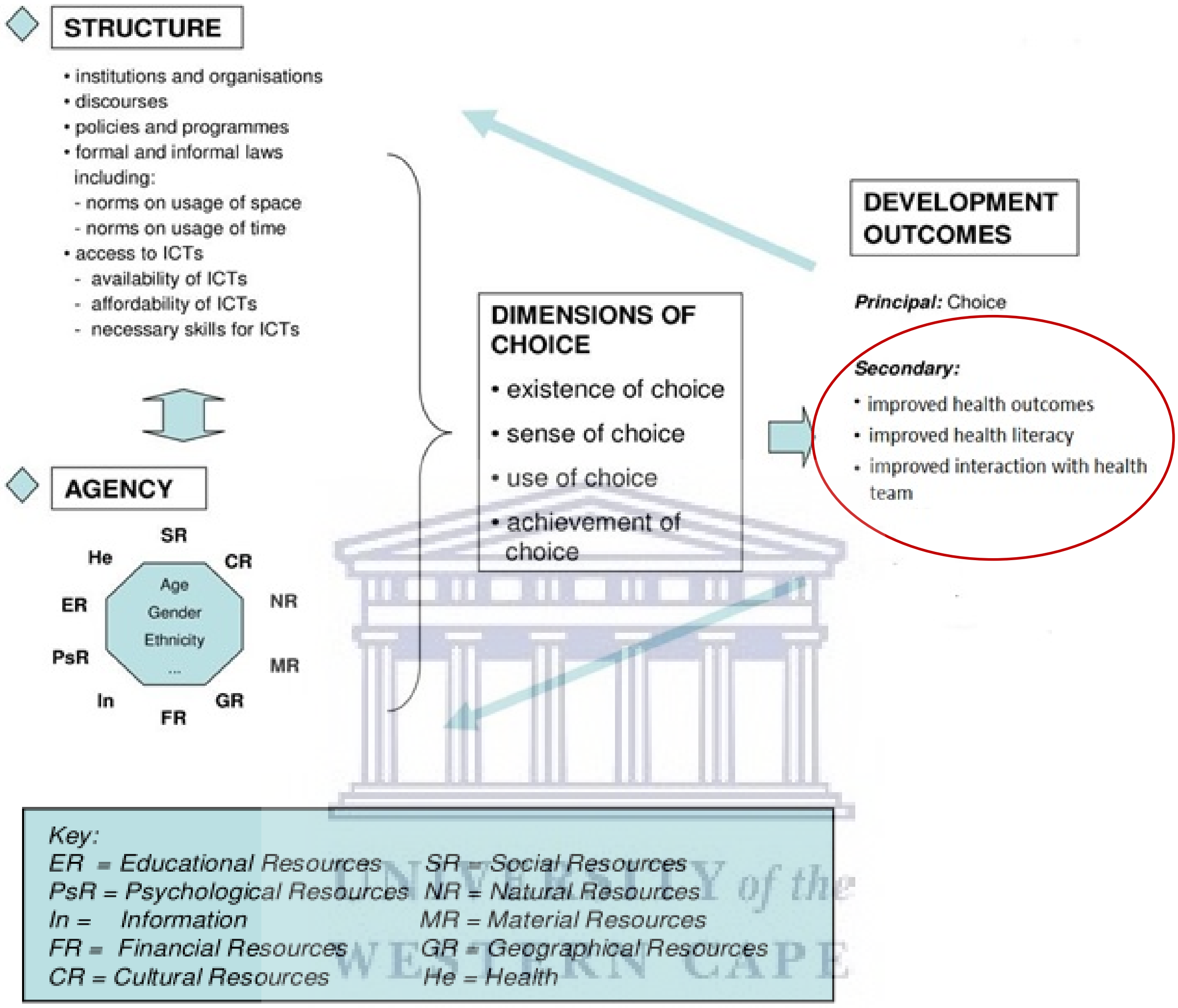


Figure 7: Choice framework
Source: Adapted from Kleine (2010:3)

While the choice framework's agency provides contextual factors to consider (e.g. educational resources and financial resources), the alternative evaluation framework identifies *context* as a specific factor. *Context* includes ICT diffusion. *Diffusion* is defined as the process "by which an innovation is communicated through certain channels over time among the members of the social system" (Rogers, 2003:5).

The framework is shown in Figure 8 also includes livelihood resources, institutional resources, capabilities and livelihood outcomes. Additionally, it links to the stages of ICT programmes, as depicted in the circles (Gigler, 2015).

Livelihood resources, similar to conversion factors in the capability approach framework, aim to explain how different types of capital influence a person's or society's capability to convert valued functionings into realised functionings. Gigler (2015) also emphasises the contextualisation of ICTs, arguing that providing ICT access to the poor will only achieve lasting and sustainable benefits if ICTs are appropriate to local needs and realities.

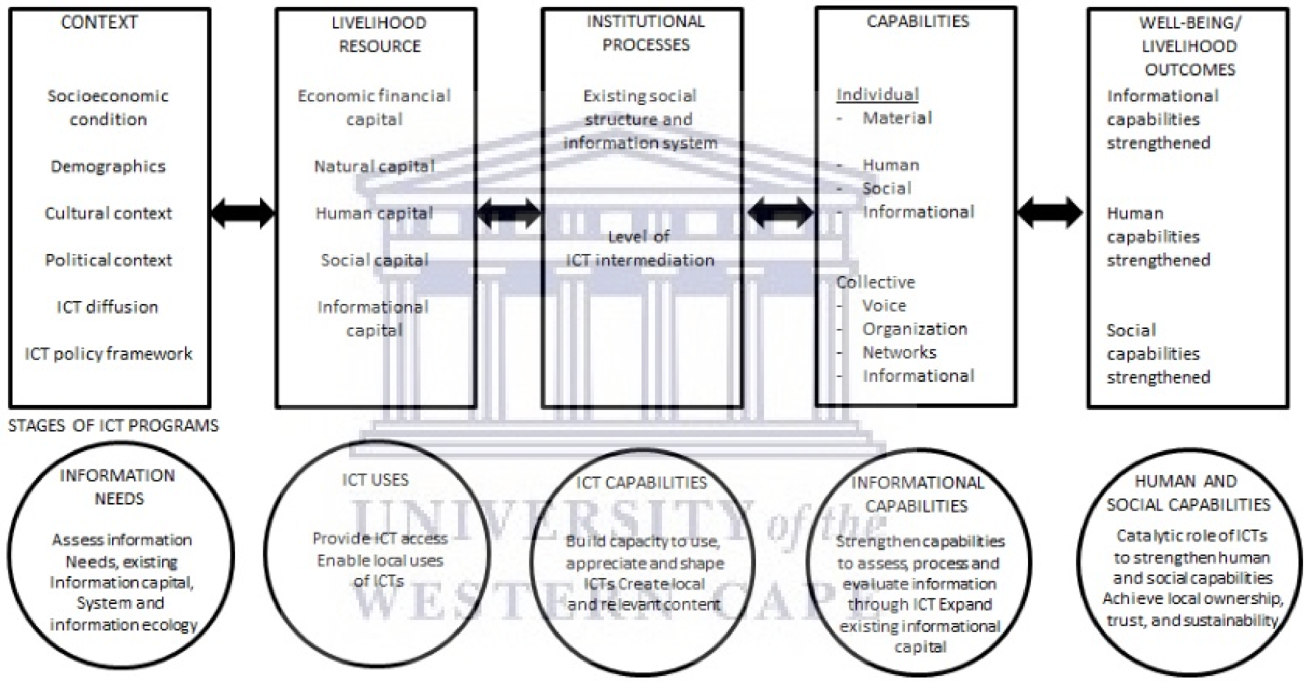


Figure 8: Alternative evaluation framework for the impact of ICTs on well-being
Source: Gigler (2015:32)

ICT4D has focused on increasing supply during the early beginning phase, yet ICT4D literature by Hefferman *et al.* (2016) acknowledges the needs for a demand for ICT, in this case, the demand for ICT that will improve the health care for patients with diabetes. The adoption of the tool and content will be impacted by access, affordability and acceptability, factors referring to *structure* in the Choice framework. These factors lead to the diffusion of knowledge and behavioural changes. Based on research by Hefferman *et al.* (2016), a mobile health intervention would need to bring about explicit behavioural changes for patients with diabetes to better manage their condition.

The measurement of ICT such as a mobile health intervention to derive these behavioural changes, however, must be observed over some time, spanning phases described by Heeks (2010):

- *Readiness:* Having the policies and infrastructure to make ICT availability possible.
- *Availability:* Rolling out ICTs to the poor to help them become users.
- *Uptake:* Implementing and applying ICT to make it useful.
- *Impact:* Using ICTs to make the greatest developmental impact.

According to Heeks (2010), readiness, availability and uptake issues will remain relevant for at least a generation but will fade alongside a greater interest in impact. It is essential to note that social and economic development goals will require a considerably lengthier period to achieve.

Key observation 21: It is important to consider context, including participative and cooperative design, indigenous development and the realisation that IT is not the only element in change efforts.

Key observation 22: Based on Gigler (2015), *context* includes several elements: socioeconomic conditions, culture, demographics, politics, ICT policy framework and ICT diffusion. These elements are likely to be relevant in the South African context when analysing the acceptance and use of m-health for diabetes self-management.

Key observation 23: In Kleine's choice framework (2010), *structures* include access to ICT as well as the necessary skills to utilise ICT to derive secondary developmental outcomes. Secondary developmental outcomes for this research may refer to improved health outcomes, health literacy and interaction with the health team for diabetic patients.

Key observation 24: A mobile health intervention would need to engender behavioural changes for diabetic patients to better manage their condition; this is impacted by structures such as access, affordability and acceptability. Providing ICT access to the poor will only achieve lasting and sustainable benefits if ICTs are suitable for and appropriate to local needs and realities.

Key observation 25: Implementing and applying ICT for usefulness (uptake) will require additional research into context and structure affecting the acceptance and use of m-health applications for diabetes self-management where usage remains low among minority groups.

2.2 Contextual factors and m-health for diabetes

The capability approach is appropriate in the area of health care as well, as informed and activated patients translate to improved health outcomes (Wagner, Austin & Korff, 1996). Patients need to be empowered to manage their NCDs.

According to Weaver *et al.* (2014), health is shaped by the resources people have available to pursue their *choice* to be healthy. *Life chances* refer to the resources available to connect patients to broader social structures (Weaver et al., 2014). A lack of resources coupled with poor choices may lower health capability. And unfortunately, lower health capability may result in morbidity.

Figure 9 is based on Sen's capability approach and shows that economic, social and cultural resources impact health capabilities, especially dietary management (Weaver et al., 2014). Maintaining a healthy diet is an important diabetes self-management activity. But lower levels of economic resources may limit dietary options, due to food cost, thereby lowering health capability. The ability to implement dietary changes may be improved or hindered by social relations and norms (socialisation) as dietary changes require the cooperation from all household members (Weaver et al., 2014). It is not surprising to note that Canadian patients with prolific economic, cultural and social resources, for example, were most able and motivated to maintain a healthy diet (Weaver et al., 2014).

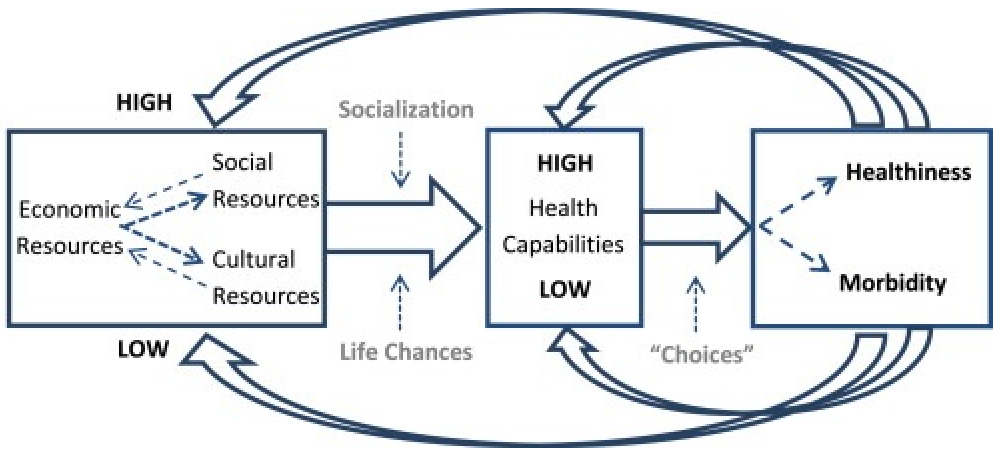


Figure 9: Capability approach for diabetes self-management
Source: Weaver et al. (2014:62)

The capability approach for diabetes self-management is supported by Wagner, Austin and Korff (1996) who insist that to manage their conditions better, patients are required to self-manage, that is, they need to manage their illness with the appropriate clinical care while they and their families cope appropriately with the illness and its therapies.

The tasks for improving chronic illness outcomes have been placed in four categories by Wagner, Austin and Korff (1996). These tasks, related to health capabilities, are as follows:

"1. Engage in activities that promote health and build a physiological reserve, such as exercise, proper nutrition, social activation, and sleep.
2. Interact with health care providers and systems and adhere to recommended treatment protocols.
3. Monitor their own physical and emotional status and make appropriate management decisions based on symptoms and signs.
4. Manage the impact of the illness on their ability to function in important roles, on emotions and self-esteem, and relations with others" (Wagner, Austin & Korff, 1996:512).

Figure 10 summarises interventions determined to be effective in meeting the above needs. Interventions for practice redesign, patient education, expert system and information can all be supported by the use of ICTs, such as m-health.

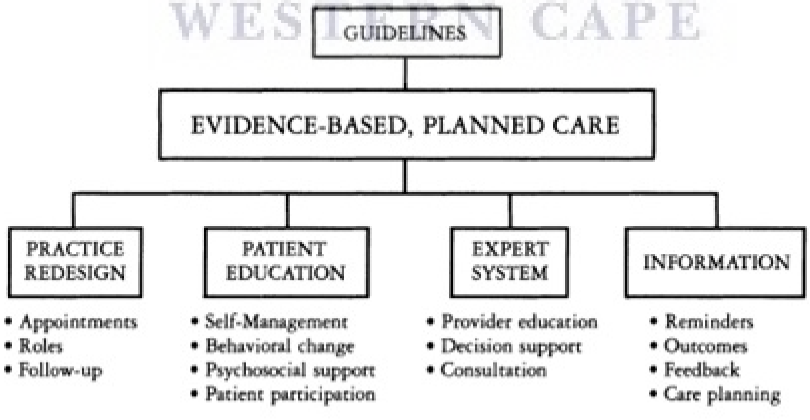


Figure 10: Improving outcomes in chronic illness
Source: Wagner, Austin & Korff (1996:520)

Chronic conditions such as DM impact patients, as DM not only requires lifelong medical treatment but carries additional burdens for controlling the disease, such as additional support required from professional caregivers, their communities and family members (Wagner, Austin & Korff, 1996; Stanton, Revenson & Tennen, 2007; Larsen & Lubkin, 2011). The support relates to Weaver *et al.*'s (2014:59) concept of *socialisation* as an "individual's lifestyle, health-related choices and behaviours remain embedded in the structures of society".

Care for patients with diabetes includes the use of self-management activities. Diabetes self-management includes monitoring physical activity, eating habits and medication-taking (Celler, Lovell & Basilakis, 2003; Gaikwad & Warren, 2009) as these are shown to improve health outcomes (Eakin *et al.,* 2002). The achievement of health outcomes leads to the attainment of developmental goals, especially in the area of chronic conditions.

Key literature indicates components for improving chronic care, of which the Chronic Care Model (CCM) was cited in several articles (Glasgow, Orleans & Wagner, 2001; Bourne, Lambert & Steyn, 2002; Barr *et al.*, 2003; Schmittdiel *et al.*, 2006; Dorr *et al.,* 2006; Kemper *et al.,* 2006; Nutting, Nelson & King, 2007; Hung *et al.,* 2008; Coleman *et al.,* 2009; Gaikwad & Warren, 2009; American Diabetes Association, 2014; Werfalli *et al.,* 2015). The CCM was developed by Ed Wagner, MD, MPH, and Director of the MacColl Institute for Healthcare Innovation, Group Health Cooperative of Puget Sound, and colleagues of the Improving Chronic Illness Care programme with support from The Robert Wood Johnson Foundation.

Self-management support is integral, as mentioned in key literature, for improving chronic care. One of the leading models, the Chronic Care Model (CCM), explains that productive interactions between the practice team and the patient are necessary to achieve improved outcomes, as evident from Figure 11.

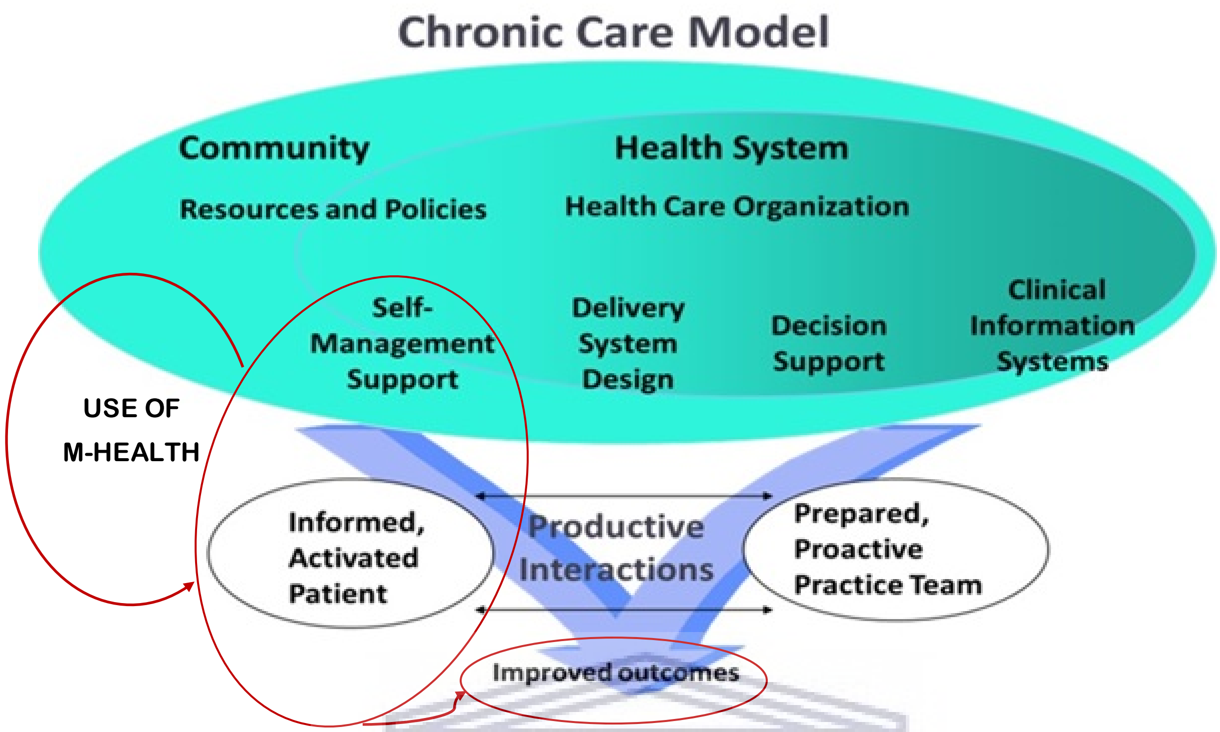


Figure 11: Chronic Care Model
Source: Glasgow et al. (2001:584)

Patients who are informed and activated have the information, confidence, motivation and skills necessary to make decisions effectively regarding the management of their health. Likewise, a prepared and proactive practice team have the patient information, decision support and resources necessary to deliver high-quality care, at the time of the interaction, to enhance both clinical and functional outcomes (Barr et al., 2003). Interventions using the CCM for diabetic patients reveal improvement in at least one process or outcome measure (Bodenheimer, Wagner & Grumbach, 2014). Therefore, this research focuses on using m-health apps as a component of self-management support to empower patients for improved outcomes as this may lead to the achievement of developmental goals (see Figure 11).

Extensions to the CCM include the Innovative Care for Chronic Conditions framework (ICCCF) introduced for LMIC (see Figure 12). The ICCF focuses on improving health care at the macro-level (e.g. policy environment), meso-level (e.g. health care organisation and community level) and micro-level (e.g. patient and family level) (WHO, 2002). The ICCF recognises that information systems should be used for health care teams (Ku & Kegels, 2015). Ku and Kegels (2015) argue that more consideration must be given to the organisation, regulation and coordination of health care services. Therefore, the ICCF model recognises that without components such as integrated policies across different disease types and prevention strategies at a macro level in LMICs, failure is more likely when applied in LMICs (Ku & Kegels, 2015).

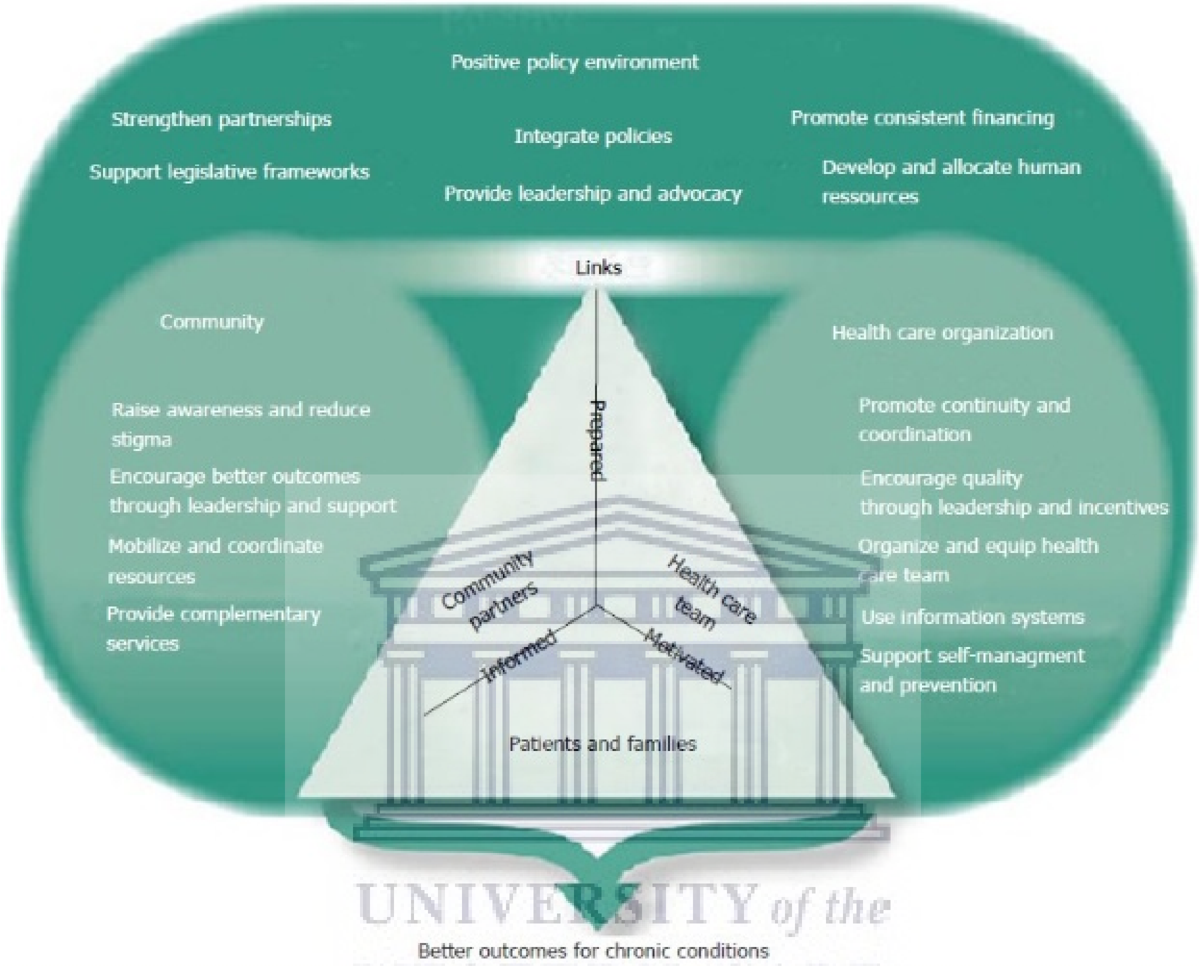


Figure 12: Innovative Care for Chronic Conditions framework
Source: Ku & Kegels (2015:570)

Barr *et al.* (2003) also recognised the opportunity to expand the CCM by integrating population health promotion to address social, environmental and cultural factors that affect health (see Figure 13). This was constructed to create better associations between the healthcare system and the community and to align the strategies for improving care (American Diabetes Association, 2015).

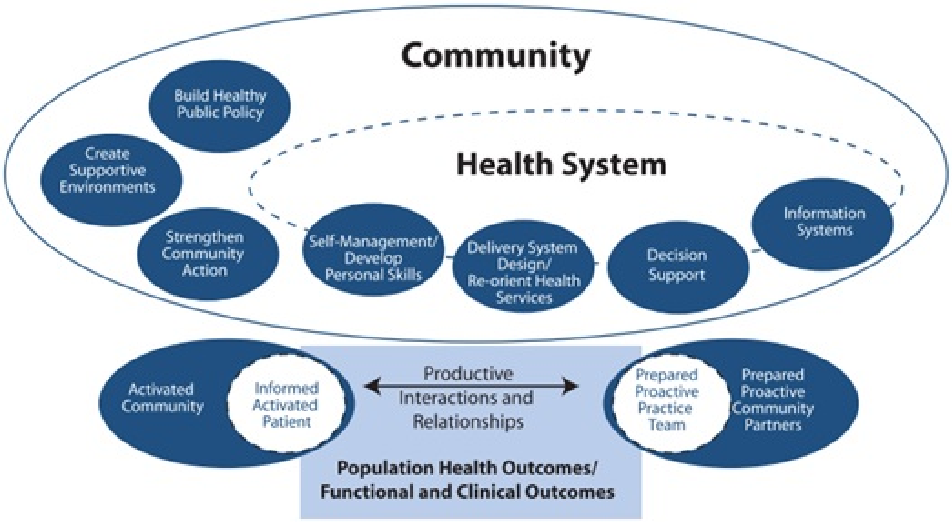


Figure 13: Expanded CCM: integrating population health promotion
Source: Barr et al. (2003)

Using ICT has been viewed as a potential solution to improve the effectiveness of the CCM (Gammon et al., 2015). The e-health enhanced CCM (eCCM) as shown in Figure 14 includes ICT while extending the existing CCM by adding the following:

- "eHealth education – critical for self-care,
- eCommunity or virtual communities – eHealth support placed within the context of community and enhanced with the benefits, and
- a complete feedback loop – assure productive technology-based interactions between the patient and provider" (Gee *et al.*, 2015:e86).

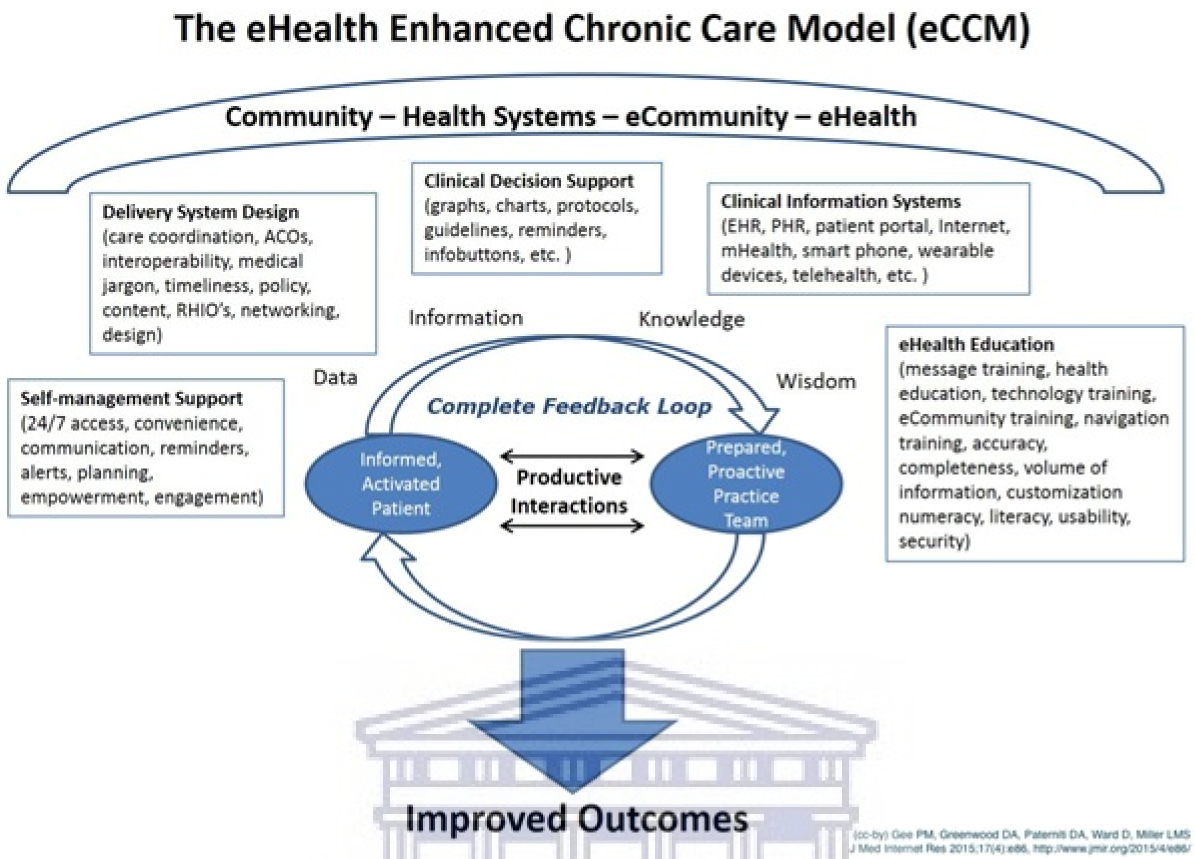


Figure 14: E-health enhanced CCM
Source: Gee et al. (2015:e86)

The CCM has also been used as a conceptual framework allowing for the inclusion for m-health for diabetic patients living in rural areas (Mallow et al., 2014). It is noted that rural populations with a low socioeconomic status have poor health outcomes due to the absence of insufficiency of primary care providers (Mallow et al., 2014). Therefore, the use of innovative technology, affording a low-cost, flexible means to supplement formal healthcare, is pivotal in reshaping the care of rural populations.

The CCM model for the inclusion of m-health includes the following additions:

- "Approved educational content, social networking and access to electronic medical records (EMR) are required. Several free EMR programmes can be incorporated into non-profit and free clinic settings.
- Bluetooth enabled devices and the use of chat, voice, and video communications allow the healthcare team to provide many of the elements of a traditional office visit.
- A delivery system redesign is needed to develop patient-centred clinical information systems within the rural health care clinic setting.
- Developing a model of healthcare delivery using m-health technologies should incorporate:

- o live technical support,
- o be easy for users,
- o include face-to-face communications,
- o have a lower cost to patients and practices than traditional interventions and
- o incorporate back-up interventions for technical issues that cannot be resolved" (Mallow *et al.*, 2014:60).

More than just for rural patients, achieving self-management may pose additional challenges to patients from any low socioeconomic community in South Africa. This is due to other factors such as experiences with public health care systems (long waiting periods and dissatisfaction from not being properly attended to by clinic staff), financial factors (cost of clinic fees and missing a day's work and wages) and transportation factors (long travelling distance and unavailability of public transport to the clinic) (Eakin *et al.*, 2002). Yet another factor is that of cultural beliefs that negatively impact on self-management (Kagee, Le Roux & Dick, 2007; Nam *et al.*, 2011).

An important notable finding is that self-management is "situation and culturally influenced; involves the ability to make decisions and perform actions directly under the control of the individual, and is influenced by a variety of individual characteristics" (Omisakin & Purity Ncama, 2011:1734). Therefore, strategies for improving care need to factor in the communication style preferences of the patient as well as patient literacy and numeracy levels. Cultural barriers to care must also be addressed, and community involvement should be supported, if feasible (American Diabetes Association 2015). This is particularly important in research contexts where the population is diverse, such as in the Western Cape.

Interventions such as patient education on self-management, behavioural change and psychosocial support are imperative. Additionally, information relating to feedback, reminders and care planning is useful in meeting the goal of improving outcomes in chronic illnesses such as DM (Wagner *et al.*, 1996). And again, these interventions can be facilitated through the use of m-health (Siminerio, 2010; Deacon et al., 2017).

Behavioural change interventions may assist in diminishing risk factors to achieve the South African Strategic Plan for the Prevention and Control of NCD by 2020. A conceptual model for planning and evaluation of behaviour change interventions targeting chronic diseases in South Africa is included in health promotion planning (Health Systems Trust, 2004). There is no evidence, however, to suggest that this method has been successfully applied in the area of diabetes, despite the high prevalence of diabetic patients in this province.

The conceptual model includes planning and evaluation phases. The following phases are applied to the research context, as seen in Table 3.

Table 3 Effective development, implementation and evaluation of behaviour change
(Adapted from source: Health Systems Trust 2004)

PHASE		APPLICATION TO RESEARCH CONTEXT
Planning	Problem	Identification of the problem – the increase in the number of patients with diabetes and diabetes as the leading cause of morbidity and mortality – especially in the Western Cape.
	Risk factors	Activities including tobacco use, unhealthy diet, physical inactivity, stress, depression, harmful use of alcohol, overweight and obesity (Vandelanotte *et al.,* 2016; Zhao, Freeman & Li, 2016).
	Behaviour	Identifying the current level of self-management of patients in the Western Cape.
	Determinants	Identifying the determinants of the behaviour, namely the contextual factors that influence self-management.
	Intervention	Assessing the use of m-health for diabetes self-management as a potential solution.
	Implementation	No implementation is intended as part of this research.
Evaluation		Evaluation of the current usage of ICT and m-health apps to gauge the impact on developmental goals. Identify improvements that can be incorporated into a framework of technology acceptance and use.

Key observation 26: Economic, social and cultural resources impact health capabilities.

Key observation 27: Innovative Care for Chronic Conditions framework recognises that information systems should be used for health care teams.

Key observation 28: E-health or m-health support needs to be placed within the context of community and enhanced with the benefits of virtual communities.

Key observation 29: M-health extension to the CCM necessitates live technical support, ease of use (effort expectancy) and face-to-face communication.

Key observation 30: Strategies for improving care need to consider culture, the communication style preference of the patient as well as patient literacy and numeracy levels.

2.3 The use of m-health applications for diabetes and developmental goals

The World Health Assembly (2018) recognises the potential for digital technologies to advance SDGs, especially the support of health care systems in all countries (World Health Assembly, 2018). ICT can support disease prevention and health promotion by improving affordability, access and quality of health services worldwide (World Health Assembly, 2018).

The use of ICT is particularly critical for the care of patients with chronic conditions such as diabetes. This is because patients not only require lifelong medical treatment but carry additional burdens in controlling the illness, such as the support required from professional caregivers, their immediate and extended communities and family members (Stanton *et al.,* 2007; Larsen & Lubkin, 2011; Wagner *et al.*,1996). Although the World Health Assembly (2018) recognises the potential to improve health service capability through the use of technology and innovation, it also argues that human interaction remains vital for the well-being of patients.

The importance of human interaction is supported by Salari *et al.* (2019) who underscore the challenges to achieving appropriate self-care due to the difficulty of living with diabetes. Good diabetes self-management requires a multilevel regime to address the required behaviour change, clinical issues and lifestyle changes. M-health demonstrates potential to support this regime that requires incessant interactions with and collaboration between patients their health care team (Salari et al., 2019).

Research describing the use of ICT as an enabler for self-management tasks performed by the patient include the use of the internet (47%), cellular phones (32%), telemedicine (12%), and decision support techniques (9%) (El-Gayar et al., 2013). ICT tools can address risk factors through the use of lifestyle modification interventions, including interventions to increase physical activity and reduce smoking (Rehman et al., 2017). The internet can be used for tasks such as sending clinical information (glucose levels and medication usage) to clinicians as well as retrieving feedback on health-related issues (Cotter et al., 2014). Cellular phones act as a mobile conduit for uploading glucose levels through the integration with a glucometer (a device used for testing blood glucose levels) as well as messaging clinicians (El-Gayar et al., 2013). Telemedicine delivers health services such as interactive, consultative and diagnostic services through the use of telecommunications (Faruque et al., 2017).

The achievement of developmental goals requires the measurement and monitoring of the level of diabetes self-management activities. This can be accomplished by using two tools: the Summary of Diabetes Care Activities or the American Association of Diabetes Educators 7 Self-care Behaviours. As stated previously, the seven self-care behaviours essential for successful and effective diabetes self-management are healthy eating, being active, monitoring, taking medication, problem-solving, healthy coping and reducing risks (American Association of Diabetes Educators, 1997). The summary of Diabetes Care Activities includes similar activities such as diet, exercise, blood-glucose testing, foot care and smoking cessation (Toobert, Hampson & Glasgow, 2000).

The monitoring of diabetes self-management can be supported through technology if, as found earlier, adherence is secured (Humble et al., 2016). ICT interventions can facilitate the process of self-care by providing educational and motivational support in their daily decision making (Siminerio, 2010; Wang *et al.*, 2017; Brew-Sam & Chib, 2019). Diabetes, in particular, is well suited to the use of clinical information technology (IT) because its management is characterised by quantifiable outcomes, such as HbA1c levels and process measures (Siminerio, 2010). HbA1c indicates the average plasma glucose over an 8-12 week period (World Health Organization, 2011). In a systematic review, 18 of 25 studies concerning technology-enabled diabetes self-management education reported a significant reduction in HbA1c as an outcome measure (Greenwood et al., 2017).

Platforms can also support the fulfilment of diabetes self-management activities. Platforms such as computer tablets and glucose monitoring devices such as continuous glucose sensors and meters can be used as ICT solutions (Drincic *et al.*, 2016) as these devices "facilitate communication and the processing and transmission of information and the sharing of knowledge by electronic means" (Hamel, 2010:1). Access to these devices and platforms heightens patient interaction frequency with their health care team.

ICT interventions can also include websites and social media. Social media has been identified as a means to deliver behavioural change intervention awareness regarding physical inactivity, diet and tobacco use. The rapid growth in popularity of social media accounts for approximately 25% of all time spent online (Ruddock et al., 2016).

Evidence indicates that patients and health workers use social media and websites to access health information (Anstey Watkins et al., 2018). However, patients needed better web search strategies as they did not know where to search or what to search for (Anstey Watkins et al., 2018). Anstey Watkins *et al.* (2018) further suggest that the use of websites and social media among health workers and patients is intermittent due to the unaffordability of airtime. Additionally, other barriers to access in South Africa, such as poor digital infrastructure and low digital literacy, are common (Department of Telecommunications and Postal Services: Republic of South Africa, 2017; Anstey Watkins et al., 2018).

The dimension of choice is accentuated for patients with diabetes due to the increased availability of m-health apps for diabetes (Bellei et al., in press). Globally, diabetes is the most popular health app category identified in the iOS Store and Android Store searched on April 27, 2017 (Deacon et al., 2017).

M-health apps have a variety of functions, the most common being the logging of clinical values such as blood sugar levels (BSL) (Deacon et al., 2017). Mobile phones are primarily used to remind patients about their clinic visits and to take their medication (Anstey Watkins et al., 2018). Miele, Eccher & Piras (2015), analysing 600 diabetes-related m-health apps, determined that the apps generally have one (54.1%) or two functions (28.2%), lack data forwarding and communication functions (68.9%) and do not offer an interface to a measurement device (95.4%).

Subhi *et al.* (2015) also analysed 6520 medical apps, of which 227 were for diabetes self-management, finding that "most medical mobile phone apps lack expert involvement and do not adhere to relevant medical evidence". In the case of diabetes apps, the research measured the adherence to evidence-based on 'inclusion of behaviours' recommended by the AADE (Subhi *et al.*, 2015:1). There were five common negative themes identified relating to how bad the app is in general: errors in networks, syncing, devices or networks; the inability of input food data relating to nutritional information; inability to enter BSL easily; the inability to backup data; as well as the loss of data (Deacon et al., 2017).

Research by Conway *et al.* (2016) identified the following diabetes app features:

- data storage and graphics;
- reminders and alarms;
- health and diet;
- exercise tracking; and
- education.

These features support the inclusion of behaviours by the AADE such as diet and exercise.

However, “results from randomized controlled trials showed a positive but modest effect of m-health on NCDs” (Beratarrechea *et al.,* 2017:13). A study in Barwala village, Delhi, India, demonstrates that an m-health intervention for health promotion and lifestyle modification at a community level can be successfully implemented in a LMIC (Sharma et al., 2017). The m-health intervention included weekly text messages and monthly telephone calls for an intervention group against a control group not receiving these messages and calls. Results in the intervention group demonstrated a substantial reduction in behavioural risk factors (unhealthy diet and insufficient physical activity) as compared to the control group. Moreover, the intervention group Body Mass Index (BMI), systolic blood pressure and fasting blood sugar level were also better than the control group (Sharma et al., 2017).

The reduction of behavioural risk factors is supported by eleven studies determining that 50% of e-health and 70% of m-health interventions were effective in promoting physical activity and healthy diets in LMIC (Müller et al., 2016). Deacon *et al.* (2017) note that reviews of Smartphone apps agree that these benefit glycaemic control as well as health education. The most common m-health intervention used in LMICs is short text messages due to the availability of resources (Beratarrechea et al., 2017; Rehman et al., 2017). Müller *et al.* (2016) believe, however, that “future interventions should use more rigorous study designs, investigate the cost-effectiveness and reach of interventions, and focus on emerging technologies, such as Smartphone apps and wearables”.

The World Health Assembly (2018) recognises the need for digital health solutions such as m-health “to complement and enhance existing health service delivery models, strengthen integrated, people-centred health services and contribute to improved population health, and health equity, including gender equality”. However, there is currently a dearth of evidence concerning the impact of digital health in these areas (World Health Assembly, 2018).

According to Nelson, Mulvaney *et al.* (2016:12), findings indicate that “racial/ethnic minorities, older adults, and persons with lower health literacy or more depressive symptoms appeared to be the least engaged in a mHealth intervention”. Also, granting universal access to health for all (SDG 3) should take into consideration the “special needs of groups that are vulnerable in the context of digital health” (World Health Assembly, 2018). Therefore, “to facilitate equitable intervention impact, future research should identify and address factors interfering with mHealth engagement" (Nelson, Mulvaney, *et al.*, 2016:12).

Müller (2016) resonates these factors by adding that m-health researchers should not focus only on the increased penetration of technology as a critical success factor for interventions, but also develop behavioural change interventions that are culturally-informed. It cannot be assumed that m-health interventions from one culture can automatically be translated into another, especially when the population and culture have escaped rigorous study (Müller, 2016).

Salari *et al.* (2019) note that "despite the growing use of mobile applications (apps) for chronic disease management, the evidence on the effectiveness of this technology on clinical and behavioural outcomes of the patients is scant". Conway *et al.* (2016) also support this view as their study indicates that despite high m-health acceptance, the current level of engagement is low. They suggest, then, that the inclusion of stakeholders in future developments, with an emphasis on clinical and user needs, may improve engagement and functionality (Conway et al., 2016).

Five additional critical success factors to improve m-health engagement include the following:

1. "Technical support to maintain, troubleshoot and train users, good network coverage, the existence of a source of energy and user-friendliness;
2. User acceptance, which is facilitated by factors such as unrestricted use of the device, perceived usefulness to the worker, adequate literacy, or previous experience of use;
3. Short- and long-term funding;
4. Organizational factors, such as the existence of a well-organized health system and effective coordination of interventions; and
5. Political or legislative aspects, in this case, strong government support to deploy technology on a large scale" (Ahmed *et al.*, 2017:1).

Ahmed *et al.*'s (2017:1) research indicate that m-health shows promise for reducing maternal morbidity and mortality in South Africa, "but knowledge on how these interventions can succeed and move to scale is limited". Additionally, the large scale deployment of an m-health intervention for improving diabetes self-management or other NCDs has not been empirically tested in this context.

Key observation 31: There is limited evidence about the effectiveness of m-health on clinical and behavioural outcomes of patients, despite burgeoning use of mobile applications (apps) for chronic disease management.

Key observation 32: There is a dearth of evidence on the impact of digital health to complement existing health service delivery models by strengthening integrated, people-centred health services.

Key observation 33: It is necessary to address health equity, thereby contributing to SDGs by improving population health. The large scale deployment of an m- health intervention for improving diabetes self-management or other NCDs has not been empirically tested in the South African context.

Key observation 34: There is a need for higher utilisation of m- health by considering the special needs of groups that are vulnerable in the context of digital health.

Key observation 35: Literature indicates that future research should identify factors impacting those least engaged in m-health interventions, such as older adults, racial or ethnic minorities and persons with lower health literacy.

2.4 Models for technology acceptance and use

Despite increased access to ICT, the promise of m-health apps for diabetes self-management will be constrained by uptake and high attrition rates (Yu et al., 2014). Therefore, the introduction of m-health apps will not in itself achieve developmental or NDP outcomes unless it is accepted and used by the intended user base, i.e. patients with diabetes (Heffernan, Lin & Thomson, 2016).

Figure 15 illustrates the conceptual framework underlying the various extant models that explain individuals' acceptance of information technology. Venkatesh *et al.* (2003) argue that individuals' reactions to information technology drive their intention to use information technology, and then ultimately determine the actual use. Research also proves that the actual use of information technology influences individuals' reactions (Venkatesh et al., 2003). For example, if using the information technology is slow and cumbersome, this will influence individuals to use it less frequently and to a lesser extent (Venkatesh et al., 2003).

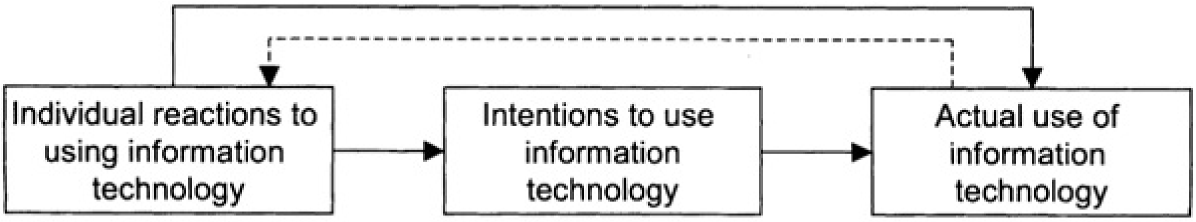


Figure 15: Concept underlying user acceptance models
Source: Venkatesh et al. (2003:427)

Seven prominent theories and models of acceptance of m-health services have been previously identified to investigate the acceptance of technology for health from a theoretical perspective (Sun et al., 2013). These seven theories and models are relevant to this problem domain and therefore investigated below.

2.4.1 The Theory of Reasoned Action

The Theory of Reasoned Action (TRA) is drawn from social psychology (see Figure 16) with the aim "to develop a theory that could predict, explain, and influence human behaviour" (Alshehri, Drew & AlGhamdi, 2013:46) within their social context (Harvey & Lawson, 2009). Its core constructs focus on attitudes toward behaviour referring to "an individual's positive or negative feelings about performing the target behaviour" and subjective norms referring to "the person's perception that most people who are important to him think he should or should not perform the behaviour in question" (Fishbein & Ajzen, 1975:129). Subjective norm is determined by an "individual's perceptions of social normative pressures (e.g., normative beliefs)" (Sun et al., 2013:185).

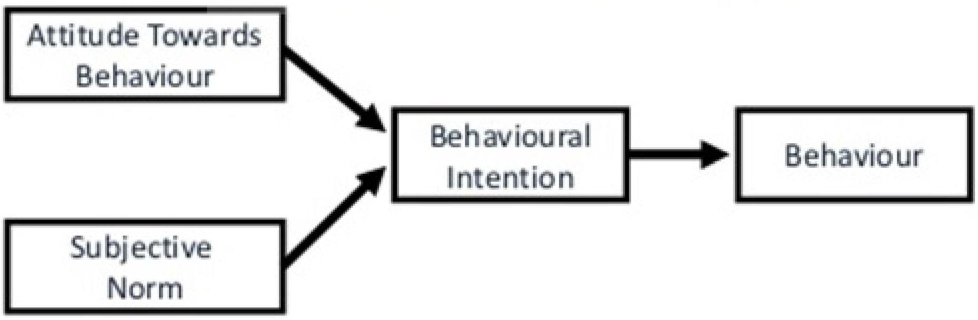


Figure 16: Theory of Reasoned Action
Source: Fishbein & Ajzen (1975:129)

This theory has predicted a range of volitional behaviours with variable success (Sheppard et al., 1988). For example, it was found that TRA has been used to predict the effect of implementation on dietary and physical activity adherence in patients with NIDDM in two studies (Didarloo *et al.*, 2012; Kurnia & Rama, 2017). In explaining regimen compliance in diabetic patients, DeWeerdt *et al.* (1990) found a relationship between intention and behaviour, with some influence on subjective norm (Harvey & Lawson, 2009). TRA and the Theory of Planned Behaviour have been relatively successful predictors of health intentions and behaviour. In one case, these explained 32-44% of the variance in intentions and 15-41% of the variance in behaviour (Nisson & Earl, 2004).

However, TRA has been subjected to criticism: intention may not always result in action, as the action may be influenced by other factors such as the cooperation of others, skills and resources (Sheppard *et al.*, 1988; Harvey & Lawson, 2009). TRA also fails to explain "irrational decisions, habitual actions, or any behaviour that is not consciously considered" (Alshehri *et al.*, 2013:47). As the model focuses on "the determinants and performance of a single behaviour" (Sheppard et al., 1988), a serious omission from the model was identified as not considering alternative options (Sheppard et al., 1988). In fact, in terms of using m-health for diabetes self-management, there are several alternatives from which users can choose (Deacon et al., 2017).

2.4.2 Theory of Planned Behaviour

Theory of Planned Behaviour (TPB), based on the work of Ajzen (1991), focuses on attitudes towards behaviour and subjective norm as in TRA (see Figure 17). Moreover, it includes perceived behavioural control (PBC) which is the "perceived ease or difficulty of performing the behaviour" (Ajzen 1991:183). This applies to behaviour where an individual does not have complete volitional control. Also, TPB takes into consideration the social systems and the roles of individual organisational members when used to predict and explain human behaviour such as health service utilisation, drinking, breastfeeding, smoking and substance use (Ajzen, 1991; LaMorte, 2018).

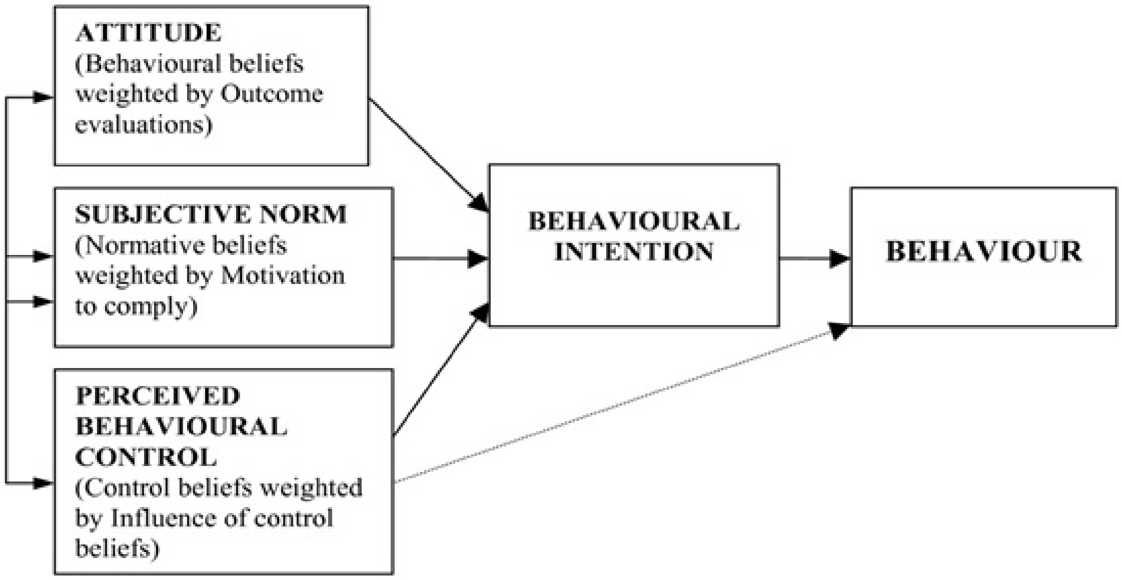


Figure 17: Theory of Planned Behaviour
Source: Ajzen (1991:182)

Despite being a psychological model and focusing on internal processes, TPB does not, however, include demographic variables. This would assume that all individuals experience the model's processes in the same way (Alshehri, Drew & AlGhamdi, 2013). Also, Perceived Behavioural Control (PBC) is an aggregated measure; in neglecting to identify specific factors, it may create biases (Alshehri, Drew & AlGhamdi, 2013).

2.4.3 Technology Acceptance Model

The Technology Acceptance Model (TAM), based on the work by Davis *et al.* (1989), is an adaption of TRA (Lee, Kozar & Larsen, 2003). It includes two key variables: perceived usefulness and perceived ease of use (see Figure 18). *Perceived usefulness* (PU) refers to "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989:320). *Perceived ease of use* (PEOU) refers to "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989:320). Perceived ease of use increases when the user believes that the system will save time and energy (Juhriyansyah, 2010).

Intention to use is determined by both perceived usefulness and perceived ease of use, which ultimately impacts usage behaviour. The relationship between perceived usefulness and intention to use (behavioural intention) was strongly significant (Lee, Kozar & Larsen, 2003).

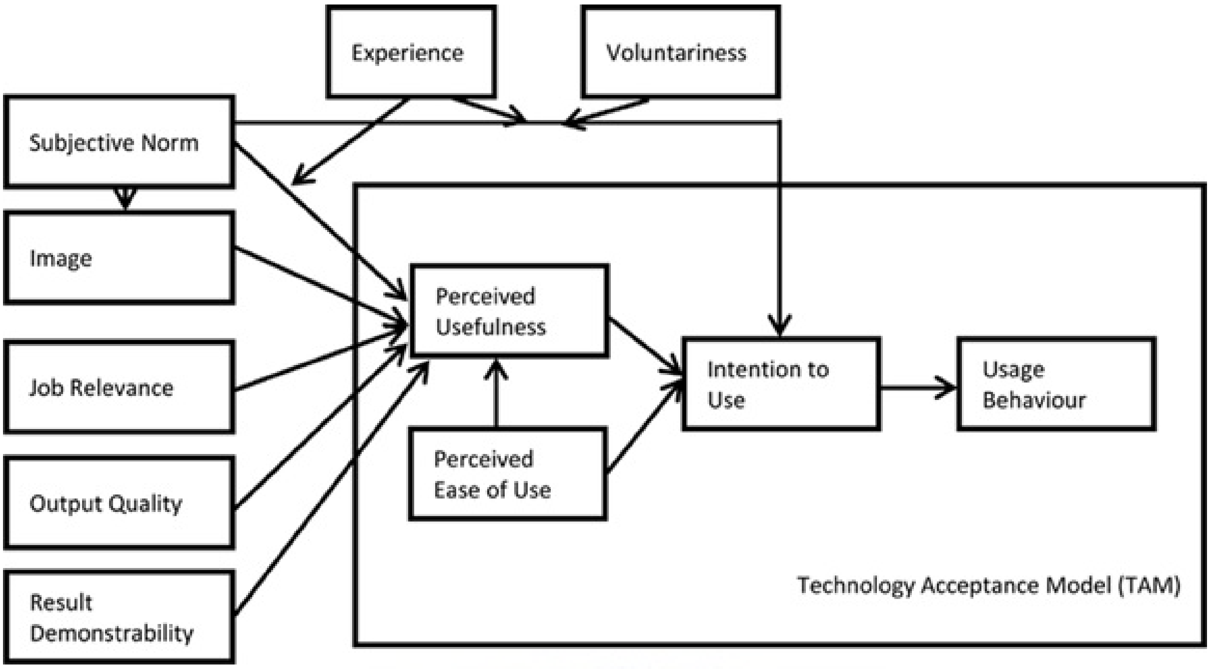


Figure 18: Technology Acceptance Model and Technology Acceptance Model 2
Source: Venkatesh & Davis (2000:188)

Hu *et al.* (1999), examining the technology acceptance model using physician acceptance of telemedicine technology, found that perceived usefulness is a significant determinant of attitude and intention, while perceived ease of use is not (Sun et al., 2013). This is supported by another study that considered factors for the adoption of m-health services among young patients in Bangladesh, found that perceived usefulness positively predicted the intention to use m-health services, while perceived ease of use was identified as a less significant factor (Hoque et al., 2015).

Also, critiques of TAM concern the reliance placed on participant self-reporting. This may inflate differences in their reported usage from their actual usage. Generalising findings may also be difficult as some studies deal with specific samples, such as students or professional users, using particular technologies (Legris, Ingham & Collerette, 2002). Holden and Karsh (2010) viewed more than 20 studies of clinicians using health IT for patient care; 16 data sets were analysed. They found "differences in samples and settings, the type of health IT investigated, research models, relationships tested and construct operationalisation" (Holden & Karsh, 2010:159). Even though TAM predicted a substantial portion of the use and acceptance of health IT, it might benefit from modifications and additions (Ducey & Coovert, 2016). An addition could include contextualisation to aid in determining the causes of generic variables such as ease of use and usefulness (Holden & Karsh, 2010).

2.4.4 Technology Acceptance Model 2

The TAM and TAM2 are designed to predict information technology acceptance and usage on the job. TAM focuses on the perceived usefulness and the perceived ease of use, while TAM2 includes additional variables allowing use in both voluntary and mandatory environments (Venkatesh & Davis, 2000), as discussed below.

TAM2 was developed specifically to address limitations inherent in TAM. As such, TAM2 includes variables such as social influence processes (image, voluntariness and subjective norm) and cognitive instrumental processes (perceived ease of use, output quality, result demonstrability and job relevance) to determine the impact on perceived usefulness (Venkatesh & Davis, 2000). *Subjective norm* refers to a person's perception that the most important people think that he should perform the specific behaviour (Venkatesh et al., 2003). Holden and Karsh (2010) insist that it is imperative to determine who the ''important others", classified as subjective norms, are. Moore and Benbasat (1991:195) define *image* as "the degree to which use of an innovation is perceived to enhance one's image or status in one's social system". Thomson *et al.* (1991) define *job relevance* as "the capabilities of a system to enhance an individual's job performance" (Lee, Kozar & Larsen, 2003:761). Venkatesh *et al.* (2000) define *output quality* as "the perception how well the system performs tasks that match with job goals" (Lee, Kozar & Larsen, 2003:762). Despite the additions to the model, TAM2 has been subjected to criticism as it does not determine the factors that influence perceived ease of use (Hasani et al., 2017).

TAM2, adapted to develop a proposed model of health IT acceptance in developing countries (Ahlan & Ahmad, 2014), aimed to examine the factors that can influence the acceptance of Clinical Decision Support System by diabetic patients in developing countries (Ahlan & Ahmad, 2014). However, since the development of this model, this has not yet been empirically tested.

2.4.5 Innovation diffusion model

The initial innovation diffusion (IDT) model, established by Rogers in 1995 (see Figure 19), proposed the foundation for researching innovation acceptance and adoption based on 508 diffusion studies (Lai, 2017).

The model consists of five phases based on prior conditions such as previous practice, level of innovation and norms of the social systems (Rogers, 2003). Each phase is summarised below:

1. During the *Knowledge phase*, individuals are introduced to innovation and subsequently learn how it functions (Rogers, 2003). This phase takes into consideration socioeconomic characteristics, personal variables and communication behaviour (Lai, 2017).
2. In the *Persuasion phase*, the perceived characteristics of the innovation, such as the complexity and compatibility, are considered. During this phase, individuals develop a positive or negative attitude towards the innovation (Rogers, 2003). This phase determines whether the technology will be accepted or not.
3. In the *Decision phase*, the individual (or unit) may be influenced by factors that either support or oppose the innovation, driving the choice to adopt or reject the innovation (Rogers, 2003).
4. Individuals or units decide to use innovation during the *Implementation phase* (Rogers, 2003).
5. In the *Confirmation phase*, the decision of continued adoption or continued rejection of innovation is secured (Rogers, 2003), but the decision may change in reaction to problems experienced with the innovation (Lai, 2017).

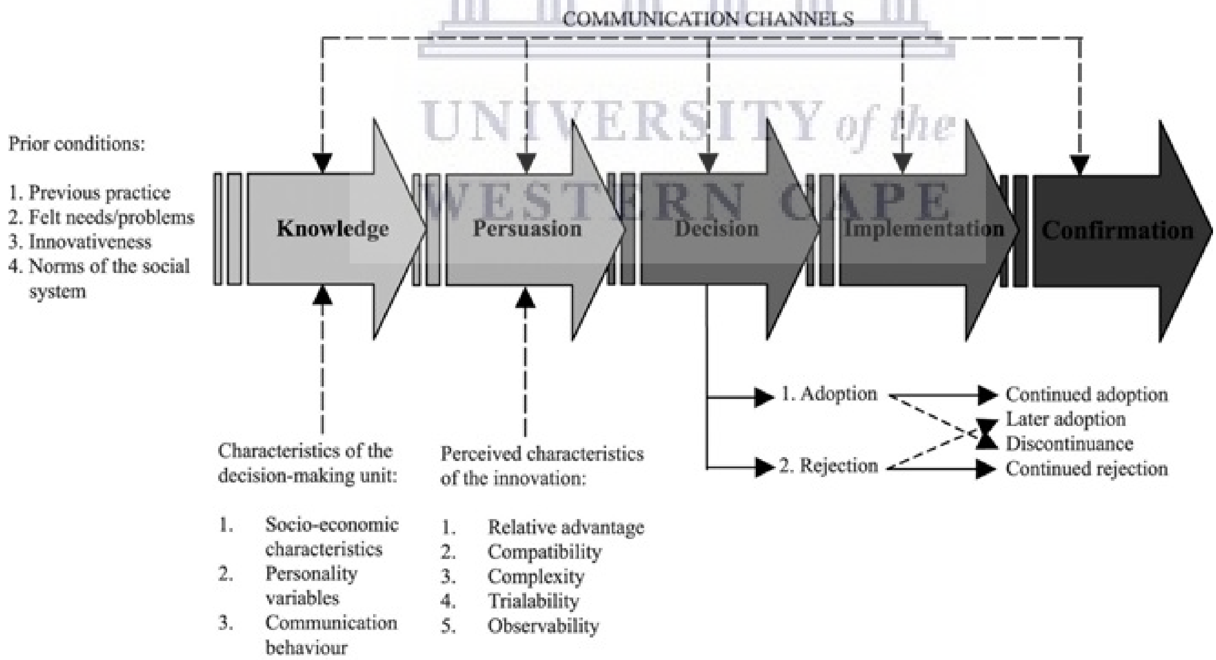


Figure 19: Innovation Diffusion Model
Source: Rogers (2003:190)

Critiques of this model contend that "complex IT solutions should be understood as socially constructed and learning-intensive artefacts, which can be adopted for varying reasons within volatile diffusion arenas" (Lyytinen & Damsgaard, 2001:1). Factors that must be considered by researchers include the importance of understanding key players in the diffusion arena as well as the role of institutional regimes and models that integrate factors such as team behaviour (Lyytinen & Damsgaard, 2001).

This model was used to investigate factors influencing patient acceptance and use of consumer e-health innovations in a primary care clinic (Zhang *et al.*, 2015). Zhang *et al.* (2015) found a low level of adoption impacted by insufficient awareness, a lack of e-skills and limited access to ICT (Zhang *et al.*, 2015).

2.4.6 Task-Technology Fit Theory

Task-Technology Fit Theory (TTFT) aims to understand the linkages between Information Systems (IS) and individual performance (Goodhue & Thompson, 1995). TTFT contains five variables: task characteristics, technology characteristics, task-technology fit, performance impacts and utilisation (see Figure 20). *Performance impact* refers to "improved efficiency, effectiveness, and/or higher quality" (Lai, 2017:23). If the fit between task and technology is good, it is assumed this will increase utilisation and performance impact as the technology more closely suited user needs (Goodhue & Thompson, 1995).

Lai (2017) indicates that this model is suitable for measuring applications already in the marketplace, such as Google Play Store or Apple Store, as it can obtain feedback when investigating the actual use of new technology.

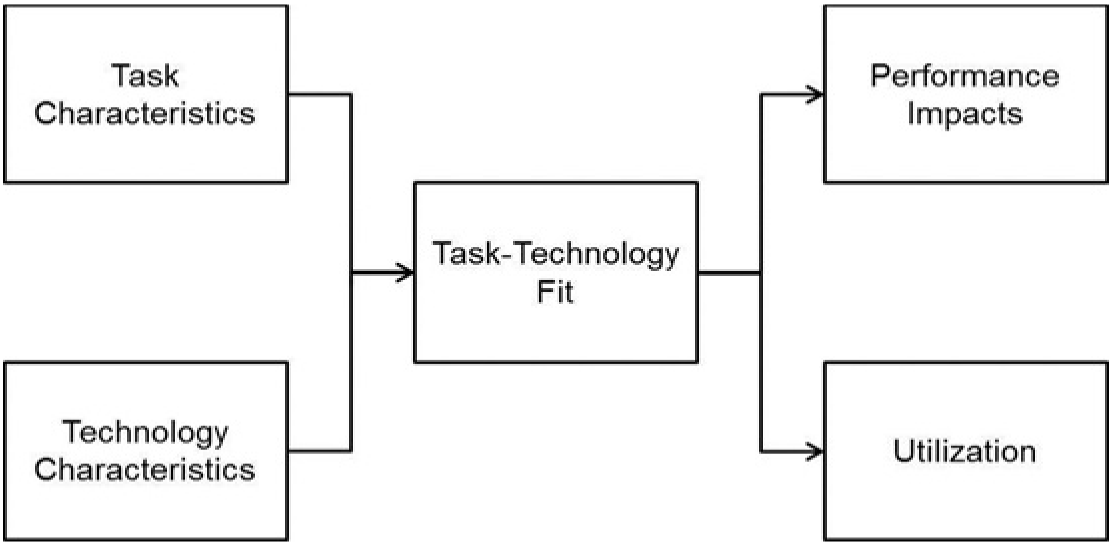


Figure 20: Task-Technology Fit Theory
Source: Goodhue &Thompson (1995:215)

TTFT, applied as a theoretical foundation to examine the task-technology alignment of m-health for Community Health Workers (CHW) in developing countries, aimed to assess the socio-technical aspects of m-health by examining the relationship between social and technical subsystems. However, this model has not yet been empirically tested (Tariq & Akter, 2011).

It is further noted that as it is difficult to measure performance impact directly, reliance is on user evaluations (Irick, 2008). User evaluations typically consist of a survey with a series of questions based on certain qualities of the information system. Responses are predicated along a continuum from positive to negative. However, these measures have been criticised by Goodhue (1995) for their lack of sound theoretical and empirical evidence.

It is also noted that culturally driven communication behaviours can either enable to hinder technology utilisation (Massey et al., 2001). Therefore, it is essential to consider cultural orientation when using TTFT for information system evaluation (Irick, 2008). Additionally, for innovation in healthcare to diffuse to patients most needing it, barriers for adoption must be addressed before launching (Dearing & Cox, 2018).

2.4.7 Unified Theory of Acceptance and Use of Technology

The Unified Theory of Acceptance and Use of Technology (UTAUT) model integrates elements across eight models: namely TRA, TAM, the Motivational model, TPB, a model combining TAM and TPB, the Model of PC Utilisation (MPCU), IDT and the Social Cognitive Theory (SCT) (Venkatesh et al., 2003).

The motivational model, combined TAM-TPB, Model of PC Utilisation and Social Cognitive Theory are all summarised by Venkatesh *et al.* (2003). The motivational model, based on research in psychology, includes factors such as extrinsic motivation ("perception that users will want to perform an activity because it leads to activities, such as improved job performance, pay or promotions") as well as intrinsic motivation ("perception that users will want to perform an activity for no apparent reinforcement other than the process of performing the activity") (Venkatesh et al., 2003:428).

Combined TAM-TPB assesses attitude toward behaviour, subjective norm, perceived behavioural control and perceived usefulness (Venkatesh et al., 2003).

The Model of PC Utilisation, primarily derived from Triadis' theory of human behaviour, presents a competing perspective to TRA and TPB. This model includes areas such as job-fit, complexity, long-term consequences, affect towards use, social factors and facilitating conditions (Venkatesh et al., 2003).

Social Cognitive Theory core variables include the outcome of expectations-performance, the outcome of expectations-personal, self-efficacy, affect and anxiety (Venkatesh et al., 2003).

The UTAUT model includes five key variables, as shown in Figure 21, is defined as follows:

1. *Performance expectancy* (PE): "is the degree to which an individual believes that using the system will help him or her to attain gains in job performance" (Venkatesh *et al.,* 2003:447).

2. *Effort expectancy* (EE): "is the degree of ease associated with the use of the system" (Venkatesh *et al.,* 2003:450).

3. *Social influence* (SI): "is the degree to which an individual perceives that important others believe he or she should use the new system" (Venkatesh *et al.,* 2003:451).

4. *Facilitating conditions* (FC): "is the degree to which an individual believes that an organisational and technical infrastructure exists to support the use of the system" (Venkatesh *et al.,* 2003:453).

5. *Behavioural intention* (BI) is defined as "the person's subjective possibility that he or she will perform the behaviour in question" (Venkatesh et al., 2003:456).

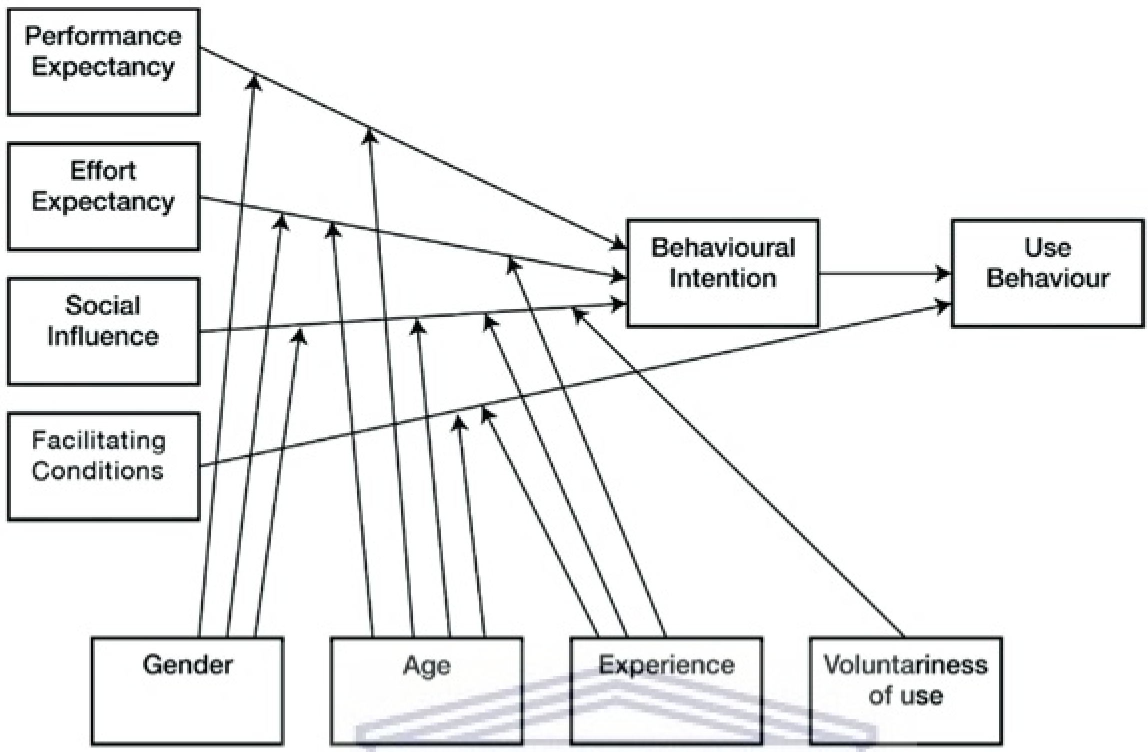


Figure 21: Unified Theory of Acceptance and Use of Technology
Source: Venkatesh et al. (2003:447)

The UTAUT model has predicted behavioural intention and use, primarily in an organisational context (Venkatesh, Thong & Xu, 2016). The model has also been employed as the theoretical framework to analyse the clinician adoption of health information systems in Cameroon (Bawack & Kala Kamdjoug, 2018). While the study was not successful in predicting usage, it did find that social influence had the most significant effect on the adoption of health information systems (Bawack & Kala Kamdjoug, 2018). However, when perceived credibility was added as a variable to assess the acceptance of e-prescribing software by Pakistani physicians, all four UTAUT variables influenced behavioural intention (Khan *et al.*, 2018).

The fact that UTAUT did not correctly predict usage in Cameroon could be supported by Venkatesh *et al.*'s (2003) critique that external factors that potentially affect the performance of a behaviour are omitted from the model. Likewise, this model neglects to consider factors such as contexts and situations that may impact usage (Venkatesh *et al.*, 2003).

A study that collected data from countries around the world, including South Africa, to cross-culturally validate the UTAUT model (Oshlyansky, Cairns & Thimbleby, 2007), results indicated that the UTAUT model can be used cross-culturally as it is robust enough to withstand translation outside its original country and language of origin, English (Oshlyansky, Cairns & Thimbleby, 2007).

2.4.8 UTAUT 2

The UTAUT model was extended by three additional variables – hedonic motivation, price value and habit (see Figure 22) (Venkatesh, Thong & Xu, 2012) – extending the model's use to a consumer rather than an organisational context (Venkatesh *et al.*, 2003). These variables can be defined as follows:

1. *Hedonic motivation* (HM) is "the fun or pleasure derived from using a technology" (Venkatesh *et al.*, 2012:161).
2. *Price value* is "consumers' cognitive trade-off between the perceived benefits of the applications and cost for using them" (Venkatesh *et al.*, 2012:161).
3. *Habit* is "the extent to which people tend to perform behaviours automatically because of learning" (Venkatesh *et al.*, 2012:161).

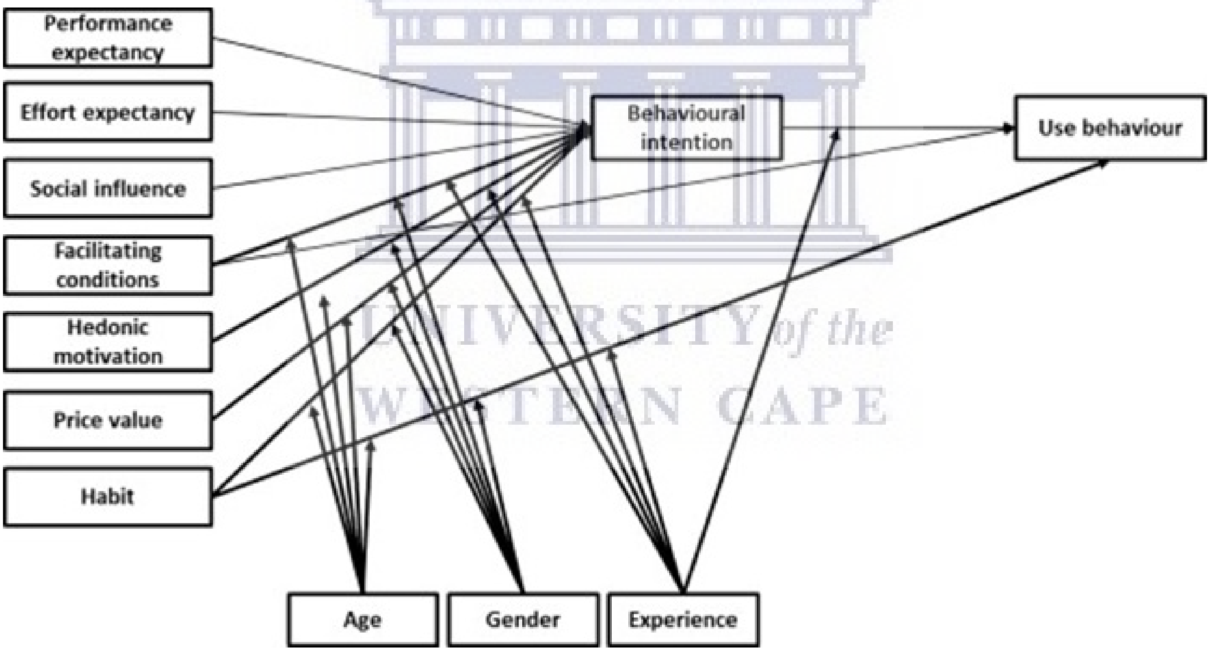


Figure 22: UTAUT2
Source: Venkatesh, Thong & Xu (2012:160)

The UTAUT2 model includes the three UTAUT moderators – age, gender and experience – but excludes voluntariness of use (Venkatesh, Thong & Xu, 2012). This is because consumer behaviour is voluntary, unlike in an organisational context, where use is likely mandated (Tamilmani, Nripendra & Dwivedi, 2017).

Sari, Othman and Al-Ghaili‘s (2019) research on mobile health technology adoption among employees at workplaces in Malaysia utilised the UTAUT2 model as a conceptual framework. It included five core variables (EE, PE, SI, FC and HM) but excluded price value and habit, finding that age and gender moderated the relationship between BI and use (Sari, Othman & Al-Ghaili, 2019).

Tamilmani, Nripendra and Dwivedi’s (2017) systematic review of citations of 650 UTAUT2 articles and its usage trends found that 77% of the articles only cited it for general citation purposes. These articles did not utilise the model in any meaningful way. The remaining 23%, if they used UTAUT2, did so in combination with external theories (Tamilmani, Nripendra & Dwivedi, 2017). This highlights the concern that UTAUT2 cannot be used as a standalone theory across technology use contexts. Additionally, the moderators of UTAUT2 were seldom used (Tamilmani, Nripendra & Dwivedi, 2017).

However, UTAUT2 extensions produced an 18% improvement over UTAUT in the variance explained in behavioural intention. Additionally, the variance explained in technology use also improved by 12% (Venkatesh, Thong & Xu, 2012).

2.4.9 Multi-level Framework of Technology Acceptance and Use

The Multi-Level Framework of Technology Acceptance and Use (MultiTAU) addresses the criticisms of the UTAUT and UTAUT2 models (see Figure 21). This results from the inclusion of two high-level areas – higher-level contextual factors and individual-level contextual factors – to the baseline model (Venkatesh, Thong & Xu, 2016).

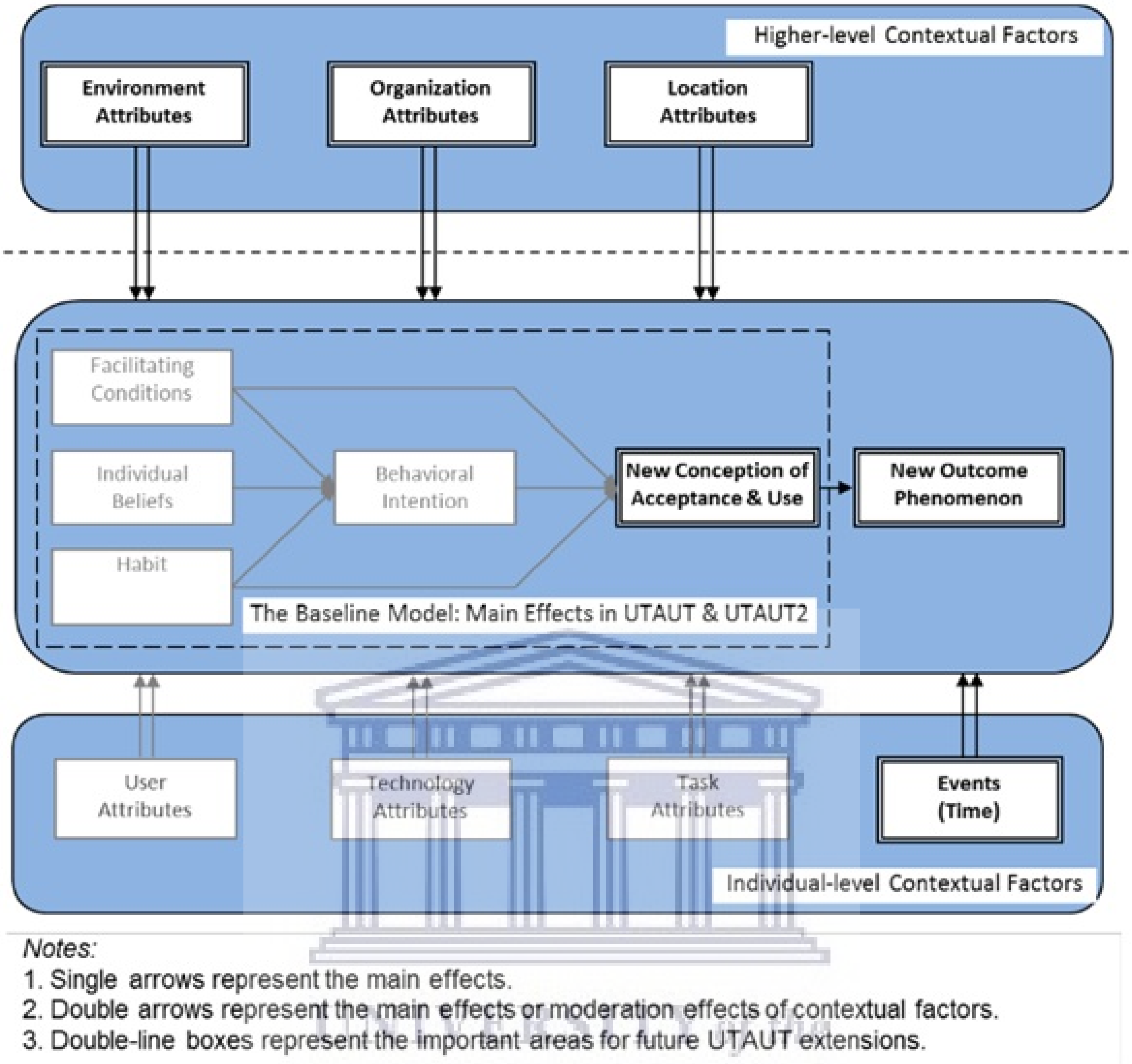


Figure 23: Multi-level Framework of Technology Acceptance and Use
Source: Venkatesh et al. (2016:347)

The baseline model is based on the primary variables from UTAUT and UTAUT2. Individual beliefs include key variables shared by the models, such as performance expectancy, effort expectancy and social influence. These individual beliefs then influence behavioural intention (Venkatesh, Thong & Xu, 2016).

Literature indicates the need to consider the context (see section 2.6), especially when assessing the impact of ICT4D. The MultiTAU model includes higher-level contextual factors, such as environmental, organisational and location attributes, defined as follows:

- *Environmental attributes* refer to "the physical environment and conditions in which the target technology is used" (Venkatesh *et al.*, 2016:344).

- *Organisational attributes* refer to "the social context of technology acceptance and use" and include items such as team climate, organisational culture and unit leadership (Venkatesh *et al.,* 2016:344).
- *Location attributes* refer to "location where the target technology is implemented or introduced" (Venkatesh *et al.,* 2016:344).

The American Diabetes Association (2015) strategies for improving care give credence to culture, the communication style preference of the patient as well as patient literacy and numeracy levels. These factors can be included in individual-level contextual factors. Individual-level contextual factors include factors such as user, technology and task attributes that may impact use, defined as follows:

- *User attributes* refer to "individuals who use technologies to assist them in performing their tasks" (Venkatesh *et al.,* 2016:344). This can include other demographic variables beyond age and gender (Venkatesh, Thong & Xu, 2016).
- *Technology attributes* refer to the "IT artefact that individual users use in carrying out their tasks" (Venkatesh *et al.,* 2016:344), including the functions and features of the technology (Venkatesh, Thong & Xu, 2016).
- *Task attributes* refer to the "goal-oriented processes and tasks supported by the target technology in turning inputs into outputs" (Venkatesh *et al.,* 2016:344). This includes the stages of the process or sequence of tasks such as software design, coding and testing.
- *Events (time)* refer to the "time relative to the implementation/introduction of the target technology" (Venkatesh *et al.,* 2016:344).

Individual-level and higher-level contextual factors represent the main moderation effects. *Moderation* implies an "interaction effect, where introducing a moderating variable (moderator) changes the direction or magnitude of the relationship" between the independent and dependent variables (Aiken & West, 1991:1). The MultiTAU model posits that adding contextual factors will moderate the effects of individual beliefs, facilitating conditions and habit on behavioural intention and use.

Despite the other identified models utilised to assess the use of ICTs for NCDs in LMICS, there was no apparent evidence in Google scholar of these models applied in the LMIC context.

Venkatesh *et al.* (2016) explain that new conceptions of acceptance and use, as well as new outcome phenomenon, represent essential areas for future research. This research represents a new outcome phenomenon for the use of m-health apps for diabetes self-management to achieve SDG 3 thereby contributing to the body of knowledge in the area of acceptance and use, as well as identifying challenges for m-health use.

Key observation 35: TRA, focusing on the causes and performance of a single behaviour, cannot account for irrational decisions.

Key observation 36: TPB extends TRA with the inclusion of perceived behavioural control. TRA and TPB have been relatively successful predictors of health intentions and behaviour.

Key observation 37: The TAM and TAM2 are designed to predict information technology acceptance and usage on the job. TAM focuses on perceived usefulness and perceived ease of use, while TAM2 includes additional variables that extend its use into both voluntary and mandatory environments.

Key observation 38: The IDT model consists of five phases (knowledge, persuasion, decision, implementation and confirmation) that evaluate prior conditions such as previous practice, level of innovation and norms of the social systems.

Key observation 39: The TTFT model aims to understand the linkages between IS and individual performance; it is essential to consider cultural orientation when using TTFT for information system evaluation.

Key observation 40: The UTAUT model integrates elements across eight models; namely TRA, TAM, the Motivational model, TPB, a model combining TAM and TPB, the Model of PC Utilisation (MPCU), IDT and the Social Cognitive Theory (SCT). These eight models used to develop UTAUT explained between 17% and 53% variance in user intentions for technology. However, the UTAUT model explained 77% of the variance in behavioural intention to use technology and 52% of the variance in technology use but is applied primarily in an organisational context.

Key observation 41: The UTAUT2 model was extended by adding three additional variables to the UTAUT model: hedonic motivation, price value and habit. This allows the model to be used for a consumer rather than an organisational context. The UTAUT2 extensions produced an 18% improvement over UTAUT in the variance explained in behavioural intention. The variance explained in technology use also improved by 12%.

Key observation 42: The Multi-Level Framework of Technology Acceptance and Use (MultiTAU) addresses criticisms of the UTAUT and UTAUT 2 models by including two high-level areas: higher-level contextual factors and individual-level contextual factors.

2.5 Potential challenges to the acceptance of m-health

Despite the availability of free m-health apps, uptake and continuous use are low (Birnbaum *et al.*, 2015; Deacon *et al.*, 2017). Research, therefore, indicates that it is essential to determine the actual barriers and facilitators to m-health apps use (Holden & Karsh, 2010).

It was found that "the effectiveness of self-management systems should be assessed along multiple dimensions: motivation for self-management, long-term adherence, cost, adoption, satisfaction and outcomes as a final result" (El-Gayar *et al.*, 2013:637) as well as the needs and limitations of the target user group.

The challenges, structured according to high-level and individual-level contextual factors, provide the basis for analysing the data collected in the domain of actual (Chapter 5) to determine the challenges for the acceptance and use of m-health apps, specifically for diabetes self-management. Additionally, the analysis gives insight into the variables that could be incorporated in the conceptual model, developed in the domain of empirical (Chapter 6).

2.5.1 Higher-level contextual factors

As shown previously in Table 1 Key observations to identify the areas for research, it is necessary to determine the context in which m-health will be implemented and used. Research indicates that context may impede the acceptance and use of m-health applications.

Access and affordability are factors that affect the usage of m-health (Heeks, 2008; Hamel, 2010; Kleine, 2010; Katz, Mesfin & Barr, 2012; Beratarrechea *et al.*, 2014, 2017). With more than a third of the Western Cape population living below the poverty line, struggling with limited device affordability and limited internet access, failing to take these very real factors into account will prohibit reaching at-risk patients.

Research already indicates mixed findings on reaching at-risk populations as most apps focus on high-cost populations (Singh *et al.*, 2016), leaving unexplored the reach to the most at-risk population groups in South Africa, who will then remain disadvantaged because the actualisation of mobile phones for aiding service access will remain confined (GSMA, 2013). It is imperative to address the cost-effectiveness challenges inherent in implementation (GSMA, 2013; Aranda-Jan, Mohutsiwa-Dibe & Loukanova, 2014). Interventions must recognise the constraints of the South African health system and consider the use of open-source options (Department of Health, 2015).

It is also necessary to consider non-technical and country-specific factors when designing and implementing ICT interventions (Waehama *et al.*, 2014). South Africa lacks resources and reliable infrastructure, such as the basic availability of adequate electricity (Aranda-Jan, Mohutsiwa-Dibe & Loukanova, 2014; Kenny & Connolly, 2017). These factors are potential barriers to the acceptance and use of m-health applications for diabetes self-management.

The South African m-health strategy 2015-2019 indicates that South Africa suffers from an absence of government leadership and coordination as well as a lack of a framework to evaluate the role of m-health and e-health tools in strengthening the health system (Department of Health, 2015). The lack of government leadership results in a lack of measurement, interoperability, alignment and integration of the interventions into health plans, strategies and systems (Department of Health, 2015), factors which challenge implementation at the primary care level with patients who cannot afford private health care treatment.

Regulators are not sufficiently engaged as there is limited scientific (health-economic) evidence for the vast majority of services compounded by inadequate incentives for the mobile industry to provide socioeconomic services (GSMA, 2013). As South Africa has a complex m-health stakeholder map, it is essential to engage stakeholders at all levels. This challenge is further related to the requirement of a single framework to evaluate the role of m-health and e-health tools in strengthening the health system (Health Systems Trust, 2015).

Contextual factors could also be the "location where the target technology is implemented or introduced" (Venkatesh *et al.*, 2016:344) and include national culture. *Culture* is context-specific and is defined as "the collective programming of the mind which distinguishes the members of one human group from another" (Hofstede, 2011:1).

According to Müller, "mHealth interventions seem to be developed and implemented in a sociocultural vacuum - the template for many mHealth interventions are mainly interventions from developed countries" (Müller, 2016:295).

It is argued that m-health interventions derived from developed countries are implemented in developing countries without taking the vast cultural differences into account (Müller, 2016). It is important to understand the cultural context and how this impacts health behaviour to be able to effectively implement m-health for behavioural change interventions.

As stated in the introduction (section 1.1.5), Western Cape statistics – such as the technological forms of exclusion, significant inequalities, a lack of internet access, low literacy and insufficient income levels in the province – could bring challenges for achieving the desired health outcomes for diabetic patients.

In South Africa, basic phones dominate devices, but access channels target those users with data and web access (GSMA, 2013). Zero-rated services, where the cost is absorbed by South African mobile operators, will be beneficial in rendering m-health services more accessible (Department of Health, 2015).

Currently, South African m-health services are based on unsustainable business models due to dependence on donor funding (GSMA, 2013; Aranda-Jan, Mohutsiwa-Dibe & Loukanova, 2014). Consequently, the risk is high for discontinuation of services. A reform for innovative business models based on best practice will help (GSMA, 2013; Department of Health, 2015).

Additionally, health apps lack evaluation (Zhang, Zhang & Halstead-Nussloch, 2014) and consumer ratings are not sufficient indicators of app usability or clinical utility (Singh *et al.*, 2016). Information provided by health apps may not be accurate or reliable. These factors underscore the need for a single framework to evaluate the role of m-health and e-health tools in strengthening the health system (Department of Health, 2015).

Key observation 43: Access and affordability are prominent factors that affect the use of m-health apps. It is necessary to address cost-effectiveness challenges in the implementation of m-health interventions.

Key observation 44: It is also important to evaluate non-technical and country-specific factors when designing and implementing ICT interventions.

Key observation 45: Interventions need effective adaptation to local contexts to prevent implementation failure.

Key observation 46: M-health interventions from developed countries are implemented in developing countries without considering the vast cultural differences.

2.5.2 Individual-level contextual factors

In order to manage NCDs such as DM, findings suggest more comprehensive interventions where several technologies are integrated. These interventions include "principles of user-centred and socio-technical design in its planning, design and implementation" (El-Gayar *et al.*, 2013:247). This is supported by Isaković *et al.* (2016) who found that including patients as part of the design team where "out-of-the-box thinking is encouraged inspires designers or care providers who develop the technologies to think differently, unconventionally, or from a new perspective". This leads to applications that are "better tailored to patients' needs" (Isaković *et al.*, 2016:2).

One particular success factor indicates that m-health needs to be individually adaptable (Aranda-Jan, Mohutsiwa-Dibe & Loukanova, 2014; Huang *et al.*, 2018). Interventions should include patients as part of the design team so that designs assess and adapt to the needs of older users (the largest group of patients with NIDDM) (Isaković *et al.*, 2016). Health apps are currently designed without user health literacy considered (Zhang, Zhang & Halstead-Nussloch, 2014).

The needs of diabetic patients are varied due to varying previous knowledge, education, age, income, type of diabetes and therapy (Scheibe *et al.*, 2015; Coetzer, 2018). Technology illiteracy is identified as a prominent barrier in low-income populations (Alvarado *et al.*, 2017). Recent studies indicate that multiple national initiatives to improve the health of older people have been only marginally successful (Werfalli *et al.*, 2019). Therefore, adequate interventions, should include the elderly as part of the stakeholder group and evaluate critical factors necessary to address the real problems. Not doing so will likely result in poor adoption and inefficient use of technology (Isaković *et al.*, 2016). Interventions should incorporate new perspectives and rely on patients' tactic knowledge (Isaković *et al.*, 2016).

Additionally, interventions need effective adaptation to local contexts with diverse populations replete with substantial educational, technological and income inequalities, to prevent project failure. South Africa has eleven official languages, for example, (Western Cape Language Committee, 2017) which will certainly prohibit the ability to use m-health applications predominantly in English.

For patients 50 years or older, ease of use (*effort expectancy*) was identified as a key factor for diabetes applications (Scheibe *et al.*, 2015). The positive impact of effort expectancy on behavioural intention is supported by other studies that analysed consumer usage of health informatics (Zhang *et al.*, 2019). However, the impact of effort expectancy on behavioural intention is more prominent for older users, as by contrast, a study of younger, well-educated users found that this relationship was insignificant (Zhang *et al.*, 2019). Therefore, diabetes applications should be designed so they are easy to use and understand, especially for older users.

Research indicates that *performance expectancy* is an important determinant of the intention to use diabetes management apps (Zhang *et al.*, 2019). This finding is supported by a study that indicates performance expectancy's significant impact on users' behavioural intention to adopt m-health services in Bangladesh (Hoque & Sorwar, 2017).

Performance expectancy influences end-user intention to use a mobile electronic medical record system (Kim *et al.*, 2015). However, performance expectancy may be low as the perception of medical professionals is that technology use and data capture is a low-status activity. Hence, the task is delegated to junior personnel (Wolff-Piggott, Coleman & Rivett, 2018). This negative perception and delegation may escalate user resistance (Wolff-Piggott, Coleman & Rivett, 2018).

Social influence was found to be a significant determinant of the intention to use diabetes management apps (Zhang *et al.*, 2019), a finding supported by the fact that supportive health care professionals and family members are integral to m-health acceptance (Macdonald, Perrin & Kingsley, 2017).

M-health data on applications such as Glucose buddy can be shared with health care providers. However, this may leave patients feeling vulnerable when health care providers fail to exude empathy or offer solutions when patients are openly sharing high glucose readings (Dadgar & Joshi, 2018).

A lack of empathy and concern by the people whom patients deem important may accelerate the discontinued use of m-health applications. The findings show that children as intermediaries in using an exercise monitoring and nutrition app encourages adults to adopt healthier lifestyles (Katule, Rivett & Densmore, 2016).

There is, quite frequently, a lack of ICT awareness that prohibits diabetes self-management and hinders diabetes-related outcomes (Waehama *et al.,* 2014; Veazie *et al.,* 2018). This may impact the acceptance of m-health applications as patients will not be aware of the existence of diabetes self-management apps and thus will not use them.

Research indicates privacy and security concerns (Singh *et al.,* 2016; Wang *et al.,* 2017). Therefore, practical approaches to privacy and security are essential (Department of Health, 2015) as patients are entering sensitive personal and health information into the apps.

Users often fear data loss and entering data incorrectly (Scheibe et al., 2015; Alvarado et al., 2017). These user fears are realised when apps do not respond appropriately after a user has entered potentially dangerous or erroneous health information (Scheibe *et al.,* 2015).

These fears are compounded by limited information technology (IT) skills and training, especially among older users (Coetzer, 2018). Health apps are downloaded and used without guidance (Huang *et al.,* 2018). Therefore, to raise the level of acceptance among older users, it is necessary to allow for trained contact personnel to assist users during the initial phase of use (Scheibe *et al.,* 2015).

Mobile applications have usability constraints such as small screens (Zhang, Zhang & Halstead-Nussloch, 2014). Small screens, difficulty in reading and typing and slow download speeds are paramount to address, especially for patients with diabetes whose eyesight may be affected by poor glycaemic control (American Diabetes Association, 2014a). These factors need to be assessed with solutions integrated into the design of m-health interventions.

Key observation 47: Applications must be adaptable and tailored to patient needs, especially for patients with lower health and technology literacy.

Key observation 48: The needs of diabetic patients may be varied due to varying previous knowledge, education, age, income, type of diabetes and therapy.

Key observation 49: Effort expectancy, social influence and performance expectancy were identified as key factors for older patients' use of m-health apps.

Key observation 50: There is often a lack of awareness of privacy and security protections for the use of m-health apps.

2.6 Gaps in the literature

The key observations listed in the preceding sections have been grouped in Table 4 to identify the gaps in the literature.

Table 4 Identifying gaps in the literature

KEY OBSERVATIONS	GROUPS	GAPS IN THE LITERATURE
Key observation 21: There is a need to consider context, including participative and cooperative design, indigenous development and the realisation that IT is not the only element in change efforts. **Key observation 22**: Based on Gigler (2015), context includes socioeconomic conditions, culture, demographics, politics, ICT policy framework and ICT diffusion. These factors are likely to be relevant in the South African context when analysing the acceptance and use of m-health for diabetes self-management. **Key observation 23**: In Kleine's choice framework (2010), structures include access to ICT as well as the necessary skills to utilise it to derive secondary developmental outcomes. Secondary developmental outcomes for this research may refer to improved health outcomes, health literacy and interaction with the health team for patients with diabetes. These factors are regarded as events in the critical realism ontology. **Key observation 24**: A mobile health intervention would need to bring about behavioural changes for patients with diabetes to manage their condition better; this is impacted by structures such as access, affordability and acceptability. **Key observation 28:** E-health or m-health support needs to be placed within the context of community and enhanced with the benefits of virtual communities. **Key observation 30:** Strategies for improving care needs to take into consideration culture, the communication style preferences of the patient as well as patient literacy and numeracy levels. **Key observation 34:** There is a need for greater utilisation of m-health by considering the special needs of groups that are vulnerable in the context of digital health.	Context	The literature in developing countries is not as prevalent as in developed countries. Hence Key observation 21: there is a need for research to take into consideration contexts such as socioeconomic conditions, culture, demographics, politics, ICT policy framework and ICT diffusion. Providing ICT access to the poor will only achieve lasting and sustainable benefits if ICTs are appropriate to local needs and realities. Strategies for improving care needs to take into consideration culture, the communication style preferences of the patient as well as patient literacy and numeracy levels. Self-management is also situational and culturally influenced by a variety of individual characteristics. These factors are specific to a particular geographical area. It is also likely to be relevant in the South African context when analysing the acceptance and use of m-health for diabetes self-management.
Key observation 25: Implementing and applying ICT to enhance usefulness (uptake) will require additional research into context and structure affecting the acceptance and use of m-health applications for diabetes self-management where usage remains low among minority groups. **Key observation 32:** There is a lack of evidence on the impact of digital health to complement and enhance existing health service	Acceptance and use of m-health applications for diabetes self-management	Key observation 25 refers to a gap in the literature. Implementing and applying ICT to enhance usefulness (uptake) will require additional research into context and structure affecting the acceptance and use of m-health applications for diabetes self-management where usage remains low among minority groups. Key observation 32 refers to the gap in the literature (i.e. lack of

delivery models by strengthening integrated, people-centred health services. **Key observation 35**: TRA, focusing on the causes and performance of a single behaviour, cannot explain irrational decisions. **Key observation 36:** TPB extends TRA with the inclusion of perceived behavioural control. TRA and TPB have been a relatively successful predictor of health intentions and behaviour **Key observation 37:** The TAM and TAM2 are designed to predict information technology acceptance and usage on the job. TAM focuses on perceived usefulness and perceived ease of use, while TAM2 includes additional variables that allow use in both voluntary and mandatory environments. **Key observation 38:** The IDT model consists of five phases (knowledge, persuasion, decision, implementation and confirmation) that consider prior conditions such as previous practice, level of innovation and the norms of the social systems. **Key observation 39:** As the TTFT model aims to understand the linkages between IS and individual performance, it is essential to consider cultural orientation when using TTFT for information systems evaluation. **Key observation 40:** The UTAUT model integrates elements across eight models: TRA, TAM, the Motivational model, TPB, a model combining TAM and TPB, the Model of PC Utilisation (MPCU), IDT and the Social Cognitive Theory (SCT). These eight models used to develop UTAUT explained between 17% and 53% variance in user intentions to use technology. However, while the UTAUT model explained 77% of the variance in behavioural intention to use technology and 52% of the variance in technology use, it is applied primarily in an organisational context. **Key observation 41:** The UTAUT2 model was extended by adding three additional variables to the UTAUT model: hedonic motivation, price value and habit. This allows the model to be used for a consumer rather than an organisational context. The UTAUT2 extensions produced an 18% improvement over UTAUT in the variance explained in behavioural intention. The variance explained in technology use also improved by 12%. **Key observation 42**: The Multi-Level Framework of Technology Acceptance and Use (MultiTAU) compensates for critiques of the UTAUT and UTAUT2 model by the inclusion of two high-level areas: higher-level contextual factors and individual-level contextual factors.		evidence on the impact of digital health to complement and enhance existing health service delivery models by strengthening integrated, people-centred health services). This is supported by the fact that little evidence was available pertaining to the likely uptake, or best strategies for engagement, efficacy or effectiveness. It is necessary to develop behavioural change interventions that are culturally-informed. The UTAUT2 model explains the biggest variance in behavioural intention and use. This model has also been tested in a health care context. However, it does not include contextual factors that are important in ICT4D. Venkatesh *et al.'s* (2016) latest Multi-Level Framework of Technology Acceptance and Use (MultiTAU) compensates for critiques of the UTAUT and UTAUT2 models by the inclusion of two high-level areas: higher-level contextual factors and individual level contextual factors. An m-health intervention for improving diabetes self-management or another NCD has not been empirically tested in the South African context, using a technology acceptance model such as MultiTAU.

Key observation 26: Economic, social and cultural resources impact health capabilities. **Key observation 27:** Innovative Care for Chronic Conditions framework recognises that information systems should be used for health care teams. **Key observation 29:** M-health extensions to the CCM include the need for live technical support, ease of use (effort expectancy) and face-to-face communication. **Key observation 31:** There is limited evidence on the effectiveness of m-health on clinical and behavioural outcomes of the patients, despite the growing use of mobile applications for chronic disease management. **Key observation 33**: It is necessary to address health equity, including gender equality, thereby contributing to SDGs by improving population health.	Impact of m-health acceptance and use on the achievement of development goals.	Based on Key observation 31, there is limited evidence on the effectiveness of m-health on clinical and behavioural outcomes of patients, despite the growing use of mobile applications for chronic disease management. Key observation 26 highlights that economic, social and cultural resources impact health capabilities. These factors are likely to impact the acceptance and use of m-health in the Western Cape context in efforts to achieve developmental goals. There is a need for this research to provide causal explanations for the low engagement with m-health apps. Therefore, the research method must consider factors such as ICT, social, organisational and environmental factors that play a causal role in low usage levels. The research will aid in the design of future interventions.
Key observation 43: Access and affordability are prominent factors that affect the use of m-health apps. **Key observation 44:** There is also a need to consider non-technical and country-specific factors when designing and implementing ICT interventions. **Key observation 45:** Interventions need effective adaptation to local contexts to prohibit implementation failure. **Key observation 46:** M-health interventions from developed countries are implemented in developing countries without taking cultural differences into account.	Challenges: • High-level contextual factors	Research already indicates mixed findings on reaching at-risk populations as most many apps focused on high-cost populations. With more than a third of the Western Cape population living below the poverty line, with the limited device and limited internet access, failing to consider these factors may result in limited reach of at-risk patients. Based on key observation 44, it is necessary to consider non-technical and country-specific factors, such as a lack of resources and unreliable infrastructure, such as the availability of electricity. Key observation 45 highlights the need to adapt to local contexts to prevent project failure. In South Africa, basic phones dominate devices, but access channels target those users with data and web access. Zero-rated services, where the cost is absorbed by South African mobile operators, will be beneficial in making m-health services more accessible. South African m-health services are also based on unsustainable business models due to the dependence on donor funding, resulting in high risk for discontinuation of services. Therefore, there is a need for innovative business models based on best practice. However, regulators are not sufficiently engaged as there is a limited scientific (health-economic) evidence base for the vast majority of services and inadequate incentives for the mobile industry to provide socioeconomic services.

		Based on key observation 46, it is imperative to understand the cultural context and how this impacts health behaviour to be able to implement m-health for effective behavioural change interventions.
Key observation 35: Literature indicates that future research should identify factors impacting the least engaged in m-health interventions, such as older adults, racial or ethnic minorities and persons with lower health literacy. **Key observation 47:** Applications must be adaptable and tailored to patients' needs, especially for patients with lower health and technical literacy. **Key observation 48:** The needs of diabetic patients may be varied due to varying levels of previous knowledge, education, age, income, type of diabetes and therapy. **Key observation 49:** Effort expectancy, social influence and performance expectancy are identified as key factors for older patients' use of m-health apps. **Key observation 50:** There is often a lack of awareness and privacy and security concerns for the use of m-health apps.	• Individual-level contextual factors	South Africa has diverse populations with significant educational, technological and income inequalities that may impact m-health acceptance and use. South Africa also has eleven official languages which will affect the ability to use m-health applications that are predominantly in English. Factors such as privacy, security, effort expectancy, social influence, performance expectancy, knowledge, education, age, income, type of diabetes and therapy are vital considerations, especially for older users. Therefore, interventions should include new perspectives and rely on patients' tactic knowledge.

2.7 Chapter summary

This chapter introduced the use of ICT, particular in the form of m-health apps, to achieve developmental goals such as attaining improved health. It is, however, essential to note that achieving health outcomes in low socioeconomic communities may be more difficult due to contextual factors. Improving health outcomes for patients with diabetes requires them to complete self-management activities.

This research examined the literature related to the theories and models of technology acceptance such as TAM, TRA, TPB, DOI, UTAUT and the MultiTAU to identify the key determinants of acceptance and use of m-health apps, for diabetes self-management in particular, and also evaluating how this can lead to the achievement of developmental goals in the area of health.

Potential challenges for the acceptance of m-health apps, specifically for diabetes self-management, was also identified as research indicates that uptake and continuous use is low, despite the availability of free options such as mobile apps. It identified both higher-level contextual and individual-level contextual factors.

The factors identified in this chapter serve as a basis for empirical testing in a diverse, low socioeconomic area to determine the impact on achieving developmental goals. The subsequent chapter provides an overview of the research design and methodology that was applied in the empirical phases of this research.

Moreover, the subsequent chapter addresses the research design and methodology used to address the gaps in the literature identified in this chapter.

CHAPTER 3 – Research Design

My PhD is a result of my need to make a difference and try to prevent others from dying from complications, like my grandmother. I am an expert in diabetes because I've had this condition for 33 years and I've tried almost EVERYTHING! How many other researchers deal with the same topic for 33 years? I've been on insulin injections; I've been admitted to hospital with diabetic ketoacidosis (high blood glucose levels), and I've almost died due to low blood glucose levels (hypoglycaemia) several times. My friend couldn't get hold of me or my family, then drove to my house. She heard my phone ringing inside but I wasn't answering. So she called the police who said that they couldn't enter my property. So, she used a brick and threw it in my lounge window, which then triggered the alarm and the security company called an ambulance. I woke up with several people around me, a drip in my arm and blood on my bed (they couldn't find my vein for the glucose drip). I couldn't remember what had happened the whole day, but my family was thinking they needed to prepare for my funeral. Despite this, I can see my examiners sitting and thinking 'Is she not going to be biased?' I've considered this very carefully and implemented various measures, such as the use of field workers to collect data and giving my research data to Honours students for their research (projects), so that I could compare their analysis to my own. Data and researcher triangulation = bias minimised.

3 Research design

The research design, a "blueprint or detailed plan for how a research study is to be conducted" (De Vos 1998:166), was considered. This study was exploratory due to the gaps identified in the literature. Exploratory research is more flexible in that it focuses on the identification of three elements:

1. boundaries of the environment in which the problem resides;
2. opportunities or situations of interest; and
3. factors or variables that might be found there and be of relevance to the research (Babbie & Mouton, 2001).

Therefore, exploratory research is suitable as the purpose of this research was to gain new insights and a better understanding of the acceptance and use of m-health apps for diabetes self-management patients in the Western Cape, where knowledge is currently limited. Although the delineation of this research is defined, it is necessary to define the contextual factors within this environment that influence m-health acceptance and use. Using exploratory research can generate hypotheses to answer 'what', 'why' and 'how' research questions (Babbie & Mouton, 2001). In the case of this study, the explorative nature of the research is highlighted by the fact that one of the objectives was to contribute to an understanding of the dynamic relationship between the acceptance and usage of m-health apps and the achievement of developmental goals.

This chapter commences with the discussion of the three predominant paradigms used in IS research as per Myers (1997). This is followed by a discussion of research methods and the application of the research design and methodology to this research. Finally, the chapter concludes with ethical considerations.

3.1 Considering paradigms

A *research paradigm* is defined as “an all-encompassing system of interrelated practice and thinking that define the nature of enquiry along three dimensions”, namely ontology, epistemology and methodology (Thomas, 2010:292). *Ontology* refers to “assumptions about the nature of reality” and may appear to be abstract initially (Saunders *et al.*, 2009:127). *Epistemology* “concerns assumptions about knowledge, what constitutes acceptable, valid and legitimate knowledge, and how we can communicate knowledge to others” (Saunders *et al.*, 2009:127). And lastly, a *methodology* is “the strategy or plan of action which lies behind the choice and use of particular methods” which in this case takes into consideration how data will be collected and analysed (Scotland, 2012:9).

3.1.1 Positivist paradigm

Social reality that is explored through a positivist paradigm is based on the work of a French philosopher, August Comte (Thomas, 2010). Underpinned by an objectivist or realistic ontology (Thomas, 2010), the positivist paradigm posits that at an ontological level, knowledge is quantifiable and objective (Mingers, 2006) as well as independent of the researcher and instruments used (Thomas, 2010). “Truth arises from a correspondence between a claim and empirically observed facts” (Avenier & Thomas, 2015:66).

Positivists use objectivism as their epistemology, as they aim to discover absolute knowledge from objective reality (Saunders *et al.*, 2009). The researcher and the researched are viewed as two independent entities (Scotland, 2012): “Meaning solely resides in objects, not in the conscience of the researcher, and it is the aim of the researcher to obtain this meaning” (Scotland, 2012:10).

Also, replication is facilitated through the use of a methodology that is highly structured (Saunders, Lewis & Thornhill, 2009). Positivists use a deductive approach in an attempt to explain relationships (Cresswell, 2014). Positivist methodology uses quantitative methods extensively as knowledge is seen to be objective and measurable (Thomas, 2010), including the use of participant observation, tests and measures, surveys and structured interviews (Easterby-Smith *et al.,* 2002).

Quantitative analysis refers to a statistical process that includes standardised measures done to empirically testing hypotheses and questions that are formulated to identify "generalizable laws" based on the relationship between the dependent and independent variables (Mcevoy & Richards, 2006). Literature indicates that the quantitative methods and positivism are used for the research on the acceptance of ICT (Venkatesh, Thong & Xu, 2016) utilising large samples of more than 200. Khan *et al.* (2018), for example, used this paradigm to assess physician acceptance of electronic prescribing in Pakistan.

However, critiques of this paradigm are "that the meaning-based nature of the social world made it inherently unavailable to external observation and measurement" (Mingers, 2006:11). Also, the ability to define causality is weakened by a poor empiricist position (Mingers, 2004).

3.1.2 Interpretive paradigm

Relativism, the ontological positioning of interpretivism (Scotland, 2012), is based on the view that reality is socially constructed and subjective (Myers, 1997). The basis of interpretivism is shared meanings and experiences; therefore it may differ from person to person (Klein & Myers, 1999). Instead of substantiating theories, interpretive researchers aim to understand phenomena through developing a rich understanding of the interaction between research subjects and their context to make sense of the world (Myers, 1997; Saunders *et al.,* 2009).

Interpretive epistemology is one of subjectivism, based on the assertion that social reality is determined from the perceptions and resultant actions of individuals (Saunders, Lewis & Thornhill, 2009). This paradigm is appropriate in IS research where the research does not examine the relationship between independent and dependent variables (Strauss & Corbin, 2008).

The *interpretive methodology* uses qualitative methods, as it is more appropriate for the understanding of social and cultural contexts and organisational functioning (Strauss & Corbin, 2008). Examples of the methodology include case studies, action research, ethnography (the study of cultural groups over a prolonged period), focus groups, grounded theory and documentary research (Scotland, 2012). *Qualitative analysis* refers to the non-mathematical process of interpretation to discover concepts and relationships in the raw data and then organises these into a theoretical explanatory scheme (Thomas, 2006).

The use of qualitative methods can assist in the identification of underlying relationships with self-management and ICT (Urowitz *et al*., 2012). A qualitative study that examines improving diabetes management with a patient portal shows that increased access to information improved engagement in health care. However, technological improvements in the portal may reduce attrition and improve usability (Urowitz *et al*., 2012). Also, literature reviews show that to find reasons for the current level of ICT acceptance, qualitative methods are used (Mcevoy & Richards, 2006) such as a study that examines the acceptance factors of mobile apps for diabetes by patients aged 50 or older (Scheibe *et al*., 2015). Wolff-Piggott *et al.* (2017) used this paradigm with open-ended interviews and observations to obtain a clinic-level perspective on the MomConnect m-health initiative, implemented in South Africa.

However, interpretivism is critiqued as it is difficult to separate the investigator from the object of the investigation because the focus is on subjective experience (Schwandt, 1994).

3.1.3 Critical realist paradigm

The critical realist paradigm is being recognised as a viable option for conducting social science research (Wynn & Williams, 2012). Based on Bhaskar (2013), critical realism considers the importance of social structures and agency. Social structure and agency are also represented in ICT4D literature. Kleine’s (2010) choice framework identifies structure and agency as critical factors in achieving developmental goals. Critical realism takes into consideration ICT and organisational, environmental and social factors, which may have played a causal role in the existence of a specific sociotechnical phenomenon (Wynn & Williams, 2012).

Therefore, it has been argued that critical realism can be applied to research concerned with ICT as it “seeks to identify those deeper lying mechanisms which are taken to generate empirical phenomena” (Alvesson & Sköldberg, 2009:40). In particular, it has been argued that critical realism can increase understanding of causal mechanisms and contexts (Mingers, 2006; Heeks & Wall, 2017). Therefore, this paradigm is relevant to this study as it aims to identify the determinants of m-health usage for diabetes self-management in a geographical area where use is not yet pervasive.

Critical realism refers to a “modified objectivist perspective” as it posits that complete objectivity is nearly impossible to achieve, although it provides the basis for guiding the search for knowledge (Thomas 2010:295). Bhaskar (2013) argues that part of reality exists independent of humans (intransitive). Bhaskar argues that *epistemology* (what we know or understand about the ‘real’) is separate from *ontology* (what we say is ‘real’ or exists). Therefore, epistemology and ontology are separate as ontological statements cannot be reduced to epistemological statements or the result will be an ‘epistemic fallacy’ (Bhaskar, 2013).

However, it is noted that the creation of knowledge, as required by a PhD thesis, occurs as a result of humans (Mingers, 2006). The creation of knowledge occurs in the transitive domain where there is a “social process drawing on existing theories, results, anomalies and conjectures (the transitive objects of knowledge) to generate improved knowledge of science’s intransitive objects” (Mingers, 2006:22). Therefore, critical realism accepts the relativism of knowledge (epistemic relativism – transitive dimension) (Avenier & Thomas, 2015:67).

The critical realist epistemic relativism posits that knowledge is contextually, culturally and historically situated (Saunders, Lewis & Thornhill, 2009; Avenier & Thomas, 2015), three factors aligning to this research as the context is an important consideration for m-health acceptance and use. Additionally, culture and historical situation are critical factors due to delineation to the Western Cape, where there is a legacy of apartheid with diverse populations suffering from significant inequalities and technological forms of exclusion.

Critical realism acknowledges that knowledge is transient (Saunders, Lewis & Thornhill, 2009). The transient view can be applied to social structures as “social structures are localised in both space and time, unlike natural laws or tendencies that are generally universal. They only hold in particular cultures or sub-cultures for finite periods of time" (Mingers, 2006:25).

Bhaskar argues that reality is hierarchically ordered (stratified) (Bhaskar, 1978). Critical realism consists of three domains: the real, the actual and the empirical (see Figure 24, adapted from Bhaskar (1978). The domain of real contains mechanisms and structures that are assumed to endure outside of the closed experimental conditions that help to empirically identify them (Archer *et al.*, 2013). Mechanisms "exist as the causal powers of things" (Bhaskar, 1978:50) while structures could be "physical, social or psychological" (Mingers, 2006:23). *Events* refer to "specific happenings resulting from causal mechanisms being enacted in some social and physical structure within a particular…context" (Williams & Karahanna, 2013:939).

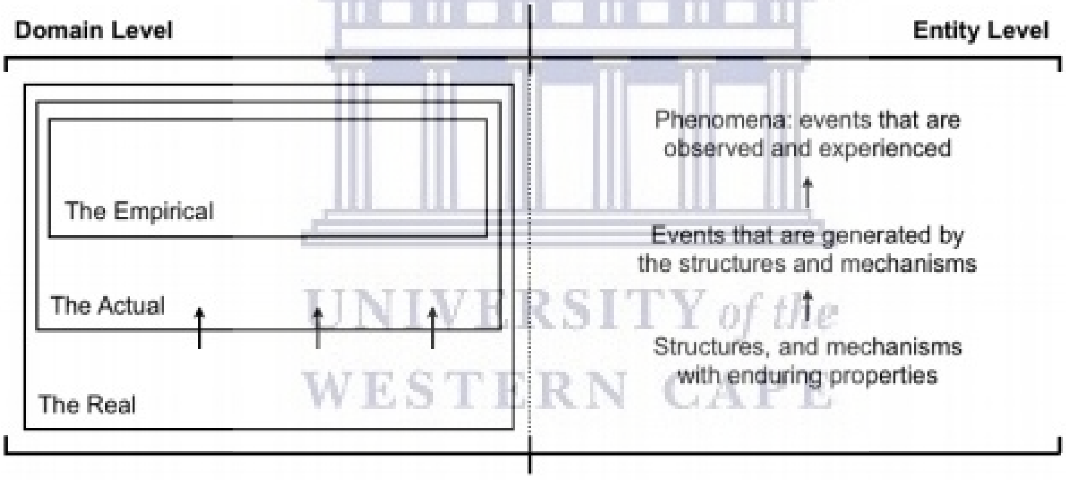


Figure 24 Stratified domains of critical realism
Source: Zachariadis, Scott & Barrett (2013:4)

Assessing the current level of diabetes self-management refers to physical, social and psychological factors in managing health. Therefore, assessment is regarded as a structure. It is vital to assess the impact of self-management activities on health outcomes due to implications on developmental goals.

Heeks and Wall (2018) argue that the mechanisms and structures in the domain of real creates the events and non-events in the domain of actual. Based on Heeks and Wall (2018), an ICT4D mechanism is access to ICT. Therefore, access to ICT, including access to the internet, may or may not be used for m-health applications in the domain of actual. Therefore, the *domain of actual* refers to the challenges of using ICT and the reasons why it does not lead to use of m-health apps. The view is supported by research that used critical realism to explain the non-adoption of broadband in rural Australia (Dobson & Jackson, 2017).

The *domain of empirical* refers to events that are actually observed and experienced (Bhaskar, 1978). The importance of context is supported by Heeks and Wall (2018:3) who state that "any experience is shaped by the context of that experience". One example of an ICT4D event may be the design of an application (Heeks & Wall, 2018). However, this research investigated the event of using existing m-health applications to perform self-management activities and achieve developmental goals.

3.2 Ontological and epistemological comparison

To identify the most appropriate paradigm for this research, a comparison of ontology and epistemology was completed (Figure 25). Interpretivism (Quinn *et al.*, 2018) and positivism (Müller *et al.*, 2016) have both been employed to research the acceptance and use of ICT for health purposes. Positivist researchers aim to discover absolute knowledge from objective reality. Positivism posits that there is one true reality and that objective reality can be identified through quantitative empirical methods.

However, interpretivism posits that reality is socially constructed and subjective. Social reality, determined from the perceptions and resultant actions of individuals, is understood through the interpretation of qualitative data.

Critical realism is seen as an alternative to positivism and interpretivism (Alvesson & Sköldberg, 2009). Critical realism, viewing epistemology and ontology as separate, was developed due to the limitations of both paradigms, including the complex nature of human social behaviour (Avenier & Thomas, 2015). Given, the importance of contextual and social structure identified in the literature (refer to section 2.6), these two factors are important considerations in this paradigm. Given that the management of diabetes is a complex medical condition that is dependent on the social behaviour of patients, this paradigm is more suitable than the selection of only interpretivism or positivism. Therefore, the use of mixed-method research is suggested to discover the underlying mechanisms that generate the empirical phenomena (Venkatesh, Brown & Bala, 2013), i.e. the determinants of acceptance and use of m-health apps, for diabetes self-management, in a particular context.

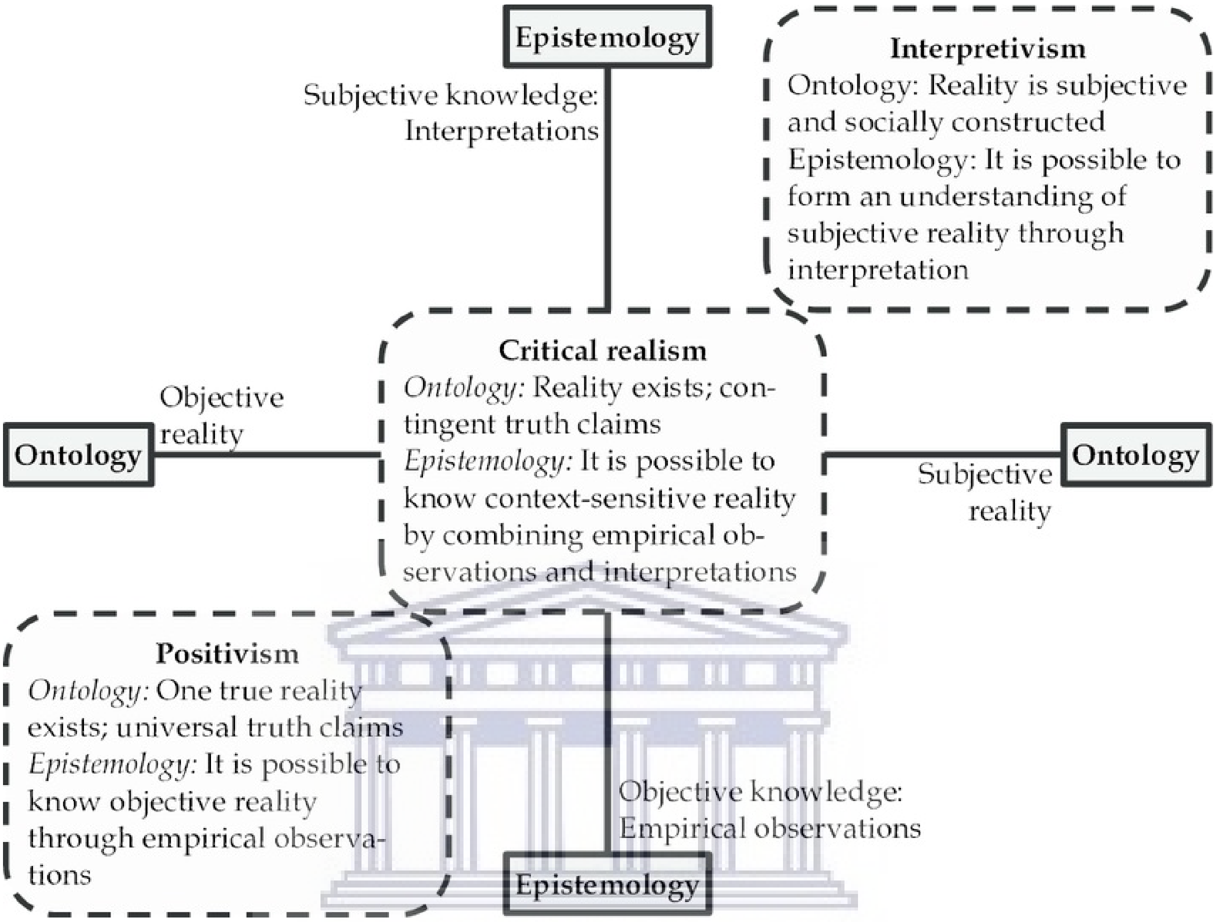


Figure 25 Ontological and epistemological comparison of research paradigms
Source: Jarvinen (2016:64)

As paradigms include ontology, epistemology and methodology, research methods are examined in the following section.

3.3 Research methods

Research methods include quantitative-, qualitative- and mixed methods. Each of these methods are discussed below.

3.3.1 Quantitative methods

Quantitative methods are used extensively in the positivist paradigm as knowledge is considered objective and measurable (Thomas, 2010). It aims to "identify objective facts based on empirical observations" without the preconceptions of the researchers (Mcevoy & Richards, 2006:67).

Quantitative method refers to a statistical process that includes standardised measures done to identify "generalisable laws" based on the relationship between the dependent and independent variables (Mcevoy & Richards, 2006:67).

For example, surveys are designed to infer statistics about a target population based on the results from a sample of that population (Fowler Jr, 2013). Surveys are a structured way to ask the same questions of large groups of people (Easterby-Smith, Thorpe & Lowe, 2002). The ability of the sample to represent the target population is based on the sampling size, the sampling frame and the "design of the selection procedure" (Fowler Jr, 2013:14). Surveys ensure that the data collected are the same (Easterby-Smith, Thorpe & Lowe, 2002). Surveys can be administered in person, via telephone, or using electronic means such as emails or online surveys (Easterby-Smith, Thorpe & Lowe, 2002). Survey data can be used to test research hypotheses (Fowler Jr, 2013).

3.3.2 Qualitative methods

Qualitative research, more appropriate for the understanding of social and cultural contexts and organisational functioning (Strauss & Corbin, 2008), is used extensively in the interpretive paradigm (Mcevoy & Richards, 2006). *Qualitative analysis* refers to the non-mathematical process of interpretation to discover concepts and relationships in the raw data and then organising these into a theoretical explanatory scheme (Thomas, 2006).

3.3.2.1 Structured interviews

Structured interviews involve the researcher asking the participant a list of predetermined questions (Easterby-Smith, Thorpe & Lowe, 2002) which can take the form of a quiz and will usually be more closed than open-ended (Cresswell, 2014). Using interviews allows the researcher to collect more detailed information with fewer participants (Thomas, 2010). This may lead to explicit and constructive suggestions (Thomas, 2010).

3.3.2.2 Semi-structured interviews

Semi-structured interviews contain a pre-planned core set of questions so that the same areas are covered in an interview (Thomas, 2010). However, this method of interviewing allows the opportunity for the interviewee to elaborate and provide other relevant information (Thomas, 2010). Using semi-structured interviews may allow the researcher to discover unobserved mechanisms.

3.3.3 Mixed methods

It is argued that a combination of quantitative and qualitative approaches leads to greater understanding, as using one is inadequate to address the complexity evident in research (Cresswell, 2014). Greene, Caracelli and Graham (1989:259) identified five broad rationales of mixed-method studies:

- "Triangulation - seeking convergence and corroboration of results from different methods studying the same phenomenon;
- Complementarity - seeking elaboration, enhancement, illustration, clarification of the results from one method with results from the other method;
- Development - using the results from one method to help inform the other method;
- Initiation - discovering paradoxes and contradictions that lead to a reframing of the research question; and
- Expansion - seeking to expand the breadth and range of inquiry by using different methods for different inquiry components".

Cresswell (2014) suggests the following designs for mixed-method studies (Figure 26):

- *Triangulation design* – Qualitative and quantitative data are collected from the same phenomenon (a). Data are then analysed for both the qualitative and quantitative investigations. The results are converged and corroborated to validate the results. These results are then interpreted, with equal weighting on both data forms.
- *Exploratory design* – This design collects data sequentially and its rationale is complementarity. As in design (b) quantitative data is collected first and then analysed. The results inform the collection of qualitative data in the second phase, allowing for the qualitative results to elaborate, enhance or clarify the quantitative results. Alternatively, qualitative data can be collected first, as in the design (c). The qualitative results are analysed and the results used to develop an instrument that will be used to collect quantitative data.
- *Embedded design* – Qualitative and quantitative data are collected simultaneously. In (d) priority is given to quantitative data. The qualitative data seeks to expand the

quantitative results. When results are interpreted, the emphasis is on the quantitative data in (d).

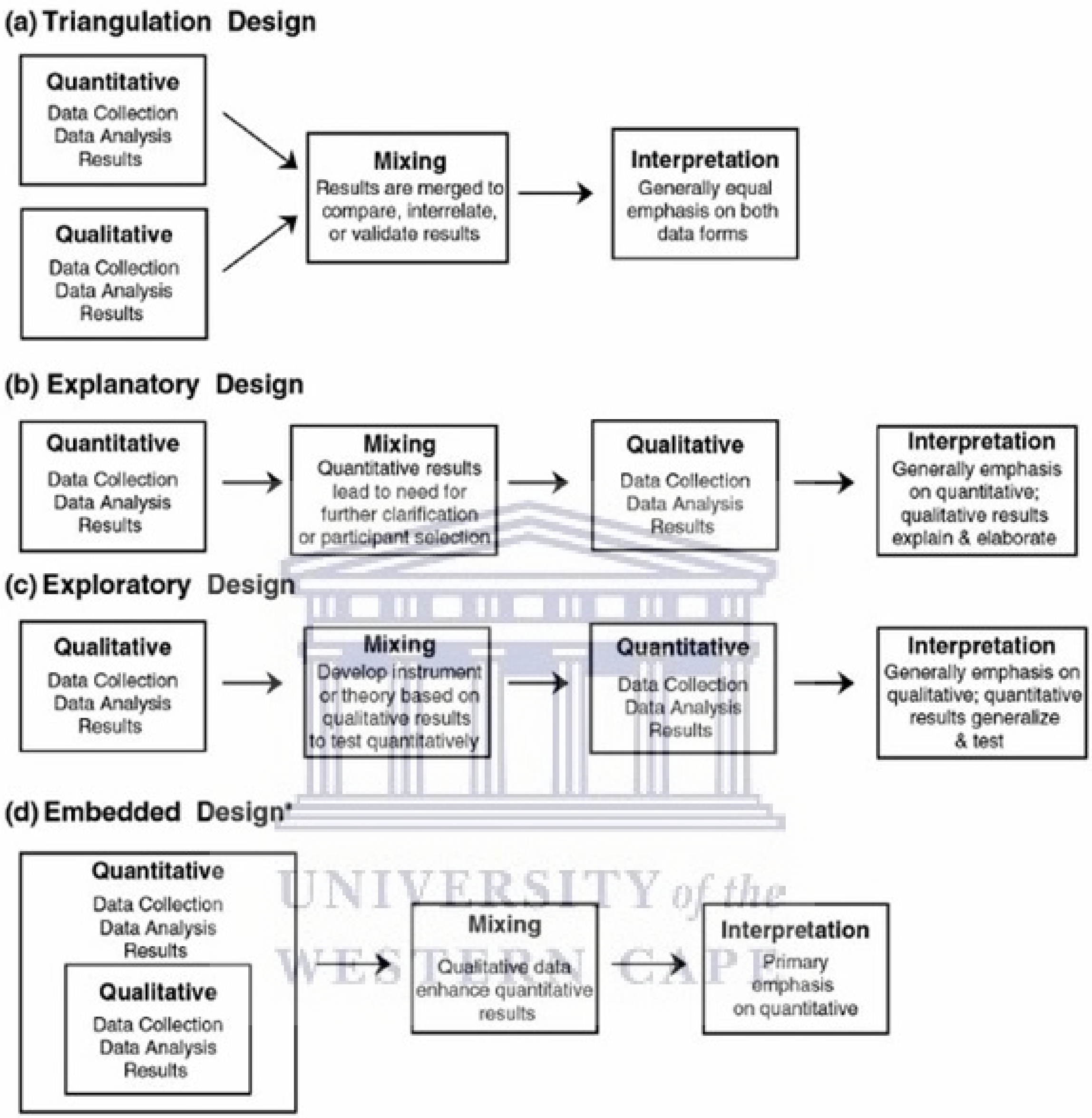


Figure 26 Mixed method designs
Source: Cresswell (2014:209)

Mixed methods in this research allowed quantitative research to be complemented by qualitative research to provide a deeper understanding (Thomas, 2010). However, it is argued that the differentiation between the types of research is simply a "paradigm war" and that there are a multiplicity of methods suitable for different types of insight (Schwandt, 2000).

3.4 Application of critical realism

The critical realism domains – the real, the actual and the empirical – were structured in this thesis as follows:

- The domain of real (Chapter 4), referring to structures and mechanisms that are endearing, leads to the generation of events (Mingers, 2004). The domain of real is important when investigating a specific contextual situation (Wynn & Williams, 2012).
- Based on Mingers (2004), the domain of actual (Chapter 5) refers to events, either observed or unobserved, that are generated when mechanisms are activated.
- The domain of empirical (Chapter 6) is as a result of events that are observed and experienced (Mingers, 2004).

Table 5 defines the mechanisms, structures and events, thereby providing the application of the critical realism domains to this study.

Table 5 Application of the critical realism domains
Adapted from Wynn & Williams (2012:791)

	DOMAIN OF REAL	DOMAIN OF ACTUAL	DOMAIN OF EMPIRICAL
Structures	✓ As stated previously, structures could be "physical, social or psychological" (Mingers, 2006:23). Therefore, based on Mingers' (2006) definition, *structures* in this research refer to the level of diabetes self-management. Diabetes affects disadvantaged populations more than in higher-income countries, and this constitutes a challenge to the achievement SDG 3. Literature indicates that people of low socioeconomic status may not have the capability to achieve optimal health functioning. Therefore, in relation to structures, the domain of real assessed the current level of diabetes self-management. The objective of the assessment indicated the extent to which m-health applications are relevant to the problem.		
Mechanisms	✓ Mechanisms have generative properties. An ICT4D mechanism includes access to ICT. Failure to have ICT access may negatively impact the ability to use m-health applications. A significant proportion of the South African population still doesn't have internet access at home (Statistics South Africa, 2018b). Therefore, the lack of this structure may impact the acceptance and m-health use for diabetes self-management. Determining the mechanisms will evaluate the access to ICT, rather than only the access to	✓ The events and non-events in the domain of actual are created by mechanisms and structures in the domain of real. In this study, the domain of real and the literature provided the basis for understanding the challenges from the use or non-use of m-health apps for diabetes self-management in this domain.	

	smartphones or the internet which is necessary for the use of m-health apps. This will allow for the discovery of other mechanisms that may be used for diabetes self-management.		
Events	✓ As stated previously, events refer to "specific happenings resulting from causal mechanisms being enacted in some social and physical structure within a particular…context" (Williams & Karahanna, 2013:939). The importance of context is supported by Heeks and Wall (2018) who state that "any experience is shaped by the context of that experience". Examples of ICT4D events may include the design of an application (Heeks & Wall, 2018). Alternatively, in this research, the use of existing m-health applications to perform self-management activities and achieve developmental goals was investigated. The investigation of the use of ICT, such as m-health, for diabetes self-management, require the use of a technology acceptance model. This domain used quantitative methods in the form of an online survey.	✓ This domain used qualitative methods in the form of semi-structured interviews. Using qualitative methods allows for potential mechanisms and structures to be discovered.	✓ Findings from the domain of real, actual and literature informed the development of the conceptual framework. The causal relationship between structure, mechanisms and events was defined. Partial least squares structured equation modelling was used to verify the relationships between the mechanisms, structures and events, identified from the literature, the domain of real and the domain of actual.

3.4.1 Selecting an appropriate technology acceptance framework

Mechanisms and structures were investigated to discover their impact on the achievement of events by using a technology acceptance framework. To choose an appropriate framework to determine the event, i.e. the use of m-health apps for diabetes self-management to achieve developmental goals, the technology acceptance frameworks were summarised in Figure 27 below. Figure 27 summarises the variables in prominent technology acceptance models in pursuit of the answer to the research question: ***What are the determinants of acceptance and use of m-health apps for diabetes self-management?***

The literature review provided the foundation to create a summary of factors prevalent in the frameworks (refer to Figure 27). TRA includes the key beliefs formulating attitude in that the attitude toward the behaviour and normative beliefs are important in determining whether individuals will perform the desired behaviour (Fishbein & Ajzen, 1975). TRA is extended by the inclusion of perceived behavioural control in TPB (Ajzen, 1991). In a comparison between TRA and TPB, the inclusion of PBC explained more of the variance in behaviour than TRA (Madden, Ellen & Ajzen, 1992). Moreover, TPB is used extensively in predicting health behaviours (LaMorte, 2018).

The innovation diffusion and task-technology fit models are antecedents to the identification of perceived usefulness and perceived ease of use, key variables in TAM. TAM compares favourably with alternative models such as TRA and TPB (Venkatesh & Davis, 2000). Adding moderators improves the predictive validity of models, except the motivational model and social cognitive theory (Venkatesh *et al.*, 2003).

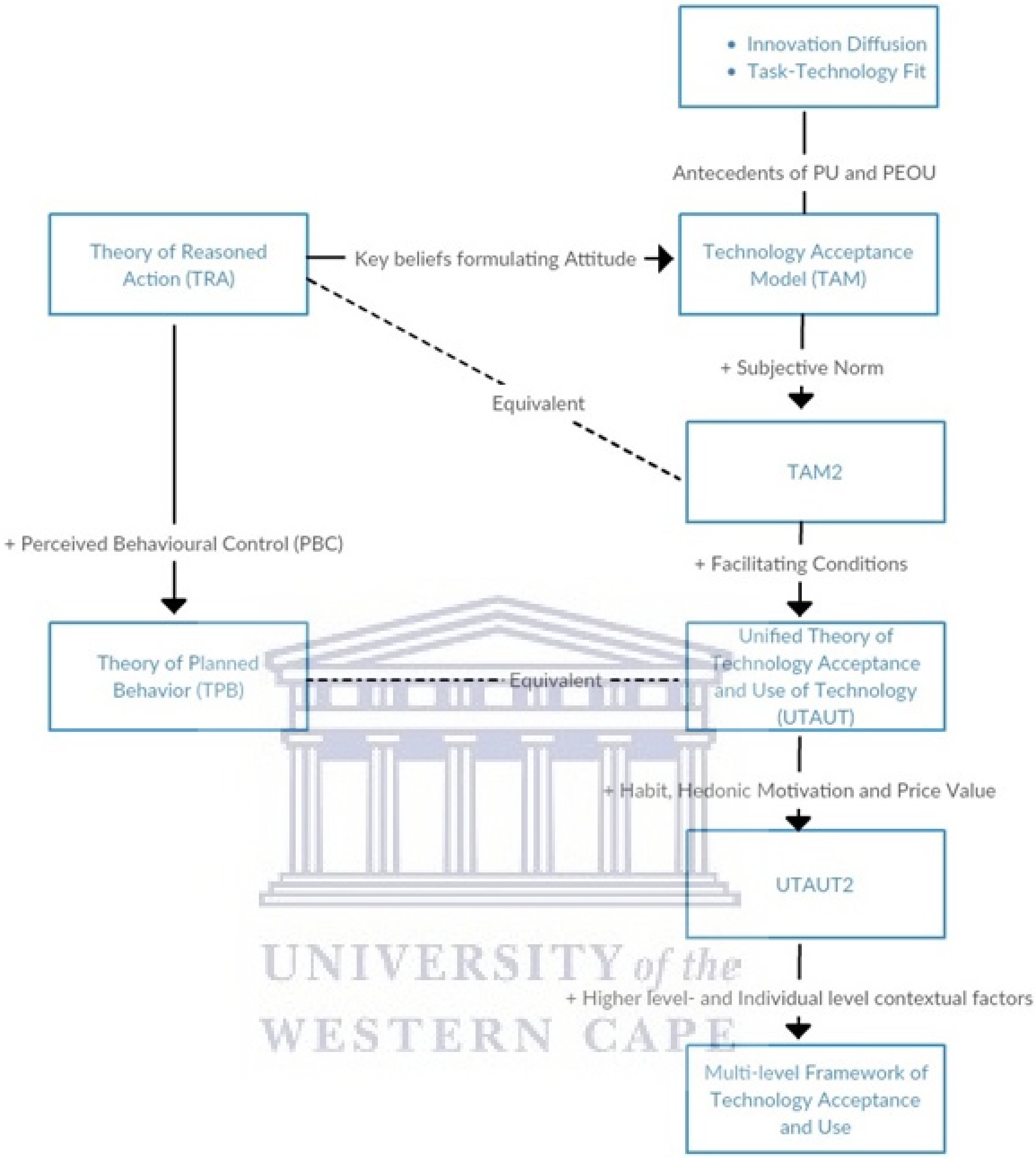


Figure 27 Summary of technology acceptance frameworks
Adapted from Sun et al. (2013:185)

The UTAUT model includes the use of moderators such as age, gender and voluntariness of use (Venkatesh *et al.*, 2003). Additionally, several studies are using UTAUT in analysing the acceptance of ICT in a health context demonstrating that the model can be successfully applied to explain the variance in behavioural intention and use (Sun *et al.*, 2013; Ahlan & Ahmad, 2014; Hoque *et al.*, 2015; Kim *et al.*, 2015; Hoque & Sorwar, 2017; Nematollahi *et al.*, 2017; Owolabi, 2017; Bawack & Kala Kamdjoug, 2018).

However, research indicates that acceptance models need to consider contexts (Schomakers *et al.*, 2018). Given the fact that the Multi-Level Framework Of Technology Acceptance and Use includes higher-level and individual-level contextual factors, it provides a suitable framework for the research context of investigating the acceptance of m-health apps among patients with diabetes. This is due to the key central variables, described in Venkatesh *et al.*'s (2016) MultiTAU model, which is sufficiently generic to be employed as an investigative lens into the analysis of m-health acceptance and use amongst diabetic patients in the Western Cape.

Based on Venkatesh *et al.*'s (2016) MultiTAU model, the following areas were selected for empirical exploration in the study:

- higher-level contextual factors:
  - environment attributes
  - location attributes
- baseline model based on UTAUT and UTAUT2:
  - individual beliefs
  - facilitating conditions
- individual-level contextual factors:
  - user attributes
  - technology attributes
- task attributes and events (time): excluded as this research did not implement a diabetes m-health application.

Organisational attributes were excluded as there was no implementation of an m-health application in an organisation. As stated, task attributes relate to the "goal-oriented processes and tasks supported by the target technology in turning inputs into outputs" (Venkatesh *et al.*, 2016:344) Events (time) include the stages of the process/sequence of tasks such as software design, coding, testing and the "time relative to the implementation/introduction of the target technology" (Venkatesh *et al.*, 2016:344). There was no implementation of m-health apps for this study, therefore, task attributes and events (time) were also excluded from the empirical investigation as these were not required to answer the research questions: ***How can the factors that influence the acceptance and use of m-health applications for diabetes self-management be synthesised into a framework of technology acceptance and use? How does this lead to the achievement of developmental goals for patients in the Western Cape, South Africa?***

3.4.2 Selecting appropriate measurement of diabetes activities

The level of diabetes self-management, to assess the achievement of developmental goals through the achievement of healthy lives, can be accomplished by two tools: the Summary of Diabetes Care Activities or the American Association of Diabetes Educators 7 Self-care Behaviours. These tools were compared to identify which tool would be more appropriate for use in this research (refer to Table 6).

Table 6 Comparison between self-management assessment tools

KEY VARIABLES	SUMMARY OF DIABETES CARE ACTIVITIES (SDCA) (Toobert, Hampson & Glasgow, 2000)	THE AMERICAN ASSOCIATION OF DIABETES EDUCATORS (AADE) 7 SELF-CARE BEHAVIOURS (American Association of Diabetes Educators, 1997)
Healthy eating	✓	✓
Being active	✓	✓
Blood-glucose testing	✓	✓
Smoking	✓	
Foot care	✓	
Taking medication	✓	✓
Self-care recommendations given by the health team	✓	
Problem-solving		✓
Healthy coping		✓
Reducing risks		✓
Used in assessing m-health applications		✓
Measures validated	✓	

The SDCA and AADE both have seven similar key variables. However, the SDCA reviewed the validity and reliability of the measures (Toobert, Hampson & Glasgow, 2000). The AADE, it was determined, has been used in studies that assessed m-health applications (Subhi *et al.*, 2015) and reusing it may not add novel ideas to the body of knowledge. Therefore, the SDCA was used to measure diabetes self-management in this study to assess the achievement of developmental goals.

3.4.3 Application of research design and methodology

This research sought to answer the following two research questions:

i) *What are the key determinants of acceptance and use of m-health apps for diabetes self-management?*

ii) *How does this lead to the achievement of developmental goals for patients in low socioeconomic communities in the Western Cape, South Africa?*

From the answers, the high-level framework, showing the research methodology in Table 7, was developed. The areas highlighted in the table will be expanded further in Chapters 4-6.

Table 7 Application of the research design and methodology

CONSTRUCT	SELECTION	JUSTIFICATION
Paradigm	Critical realism	The nature of human behaviour, especially in a health context where diabetes may lead to morbidity, is complicated. The acceptance and use of ICT rely predominantly on positivist paradigms (Venkatesh, Thong & Xu, 2016). Literature indicates that the acceptance and use of m-health are low. Therefore, this research identifies factors underlying acceptance and use, and additionally, how this impacts the achievement of development goals, i.e. performing self-management activities for patients with diabetes. According to Mingers (2006), understanding the impact of use on the achievement of development goals requires an investigation of the underlying structures, mechanisms and events that generate the currently low levels of m-health use.
Ontology	Modified objectivist perspective	A part of reality exists independent of humans (intransitive) and complete objectivity is nearly impossible to achieve, although it provides the basis for guiding the search for knowledge.
Epistemology	Relativism	Relativism posits that knowledge is contextually, culturally and historically situated.
	• Domain of real	The domain of real investigated structures, mechanisms and events. *Structures* in this research referred to the current level of diabetes self-management. The question was expanded further to assess the impact on developmental goals: 1. the current level of diabetes self-management; 2. the current risk factors; and 3. the current disease burden in terms of diabetes complications (Health Systems Trust, 2004; National Planning Commission, 2012). *Mechanisms* referred to access to ICT (Kleine, 2010). The broader ICT term was used in this domain as it is

		possible to use alternate ICT options for diabetes self-management. Investigating ICT allowed for the discovery of other mechanisms besides m-health apps *Events* refer to determining**: What is the current use of ICT for diabetes self-management to achieve developmental goals?**
	• Domain of actual	Domains of actual refer to events or non-events that are generated when mechanisms are activated. It is vital to understand the underlying reasons for the current level of acceptance and use of m-health apps for diabetes self-management as research indicates low uptake and lack of continuous use of m-health apps (Deacon *et al.,* 2017; Birnbaum *et al.,* 2015). This domain will be used to identify **the challenges for the acceptance and use of m-health apps for diabetes self-management.** The challenges identified will indicate conditions that may prevent the achievement of developmental outcomes.
	• Domain of empirical	The domain of empirical is a result of events that observed and experienced (Mingers, 2004). The MultiTAU model was expanded with factors identified in the domain of real, the domina of actual and literature. Higher-level and individual-level contextual factors were included to achieve the final research questions: **How can the factors that influence the acceptance and use of m-health applications for diabetes self-management be synthesised into a framework or model of technology acceptance and use?**
Methodology	Mixed methods	The domain of real utilised quantitative methods using an online survey. The domain of actual utilised qualitative methods, using semi-structured interviews (Myers, 1997), collected as part of phase 1 in 2017. The domain of empirical utilised quantitative methods also using an online survey. This was collected by field workers as part of phase 2 in 2018.

Target Population	Patients with diabetes residing in the Western Cape	The 2018 mid-year population estimates for South Africa by province indicates a Western Cape population of 6 621 100 (Statistics South Africa, 2018c). With the national diabetes prevalence estimated at 8.39% (Statistics South Africa, 2016), this would equate to a target population of 555 510.29 people with diabetes. A sample size of 500 equates to 9% of the total population. A minimum sample size of 384 was required for a 95% confidence interval (Raosoft, 2019).
Sampling	Purposive	Purposive sampling was used in the domain of real and the domain of empirical as this research focuses on patients with diabetes living in the Western Cape (Marshall, 1996). Random sampling was used in the domain of actual as there was not enough time or resources to interview the entire sample of 497 purposively sampled respondents. Additionally, qualitative samples can be smaller so a sample of 131 respondents was deemed adequate.
Pilot Study	Sixty online surveys and interviews were administered to a representative sample of the target population	The pilot survey was administered by the researcher to highlight inconsistencies and biases in the survey that could have affected the findings. It identified that older patients were not familiar with certain key concepts, such as ICT, and were not comfortable using an online survey. Therefore, it was decided to use third-year Information Systems students to collect the data.
Data Collection		Quantitative data for the domain of real and qualitative data for the domain of actual were collected concurrently. Third-year Information System students were trained and deployed as field workers, completing online surveys on behalf of patients with diabetes as it was necessary to explain certain concepts to obtain more accurate and reliable information. Further information regarding data collection is provided in Chapters 4-6.
	• Domain of real	A total of 528 responses were collected using an online survey. After data cleansing, removing responses that had more than 10% missing values and values not all the same (standard deviation=1) (Gaskin, 2016), 497 responses were utilised. A 6-point Likert scale (from Not At All True to Very True) was used.

	• Domain of actual	A sample of 131 respondents were interviewed using semi-structured interviews. Interviewers asked respondents questions to elaborate on quantitative results. This study used semi-structured interviews designed to question diabetic patients' habits, rituals and experiences. The interview questions were aimed at understanding the patients' perceptions of technology acceptance using the MultiTAU key variables as a basis. Also, various questions were posed that assessed whether any correlation existed between people's contextual factors and their technology acceptance.
	• Domain of empirical	To test the conceptual framework, a total of 541 responses were collected via field workers using an online survey. After data cleansing, removing responses that had more than 10% missing values and all the same values (standard deviation=1) (Gaskin, 2016), 514 responses were utilised, exceeding the 384 minimum sample size of 384 required for a 95% confidence interval (Raosoft, 2019).
Data Analysis	• Domain of real	Quantitative data in the survey were analysed via descriptive and linear regression statistics using SPSS software (Diez, 2012). The survey questions were based on the core variables inherent in the UTAUT and the UTAUT2 model adapted for this research (Venkatesh *et al.,* 2003).
	• Domain of actual	This research, using thematic content analysis, identified common themes and issues related to the acceptance and use of ICT. With a focus on the acceptance and use of m-health apps for diabetes self-management. Drawing on the literature review, the themes identified in the MultiTAU model served to identify barriers to the successful acceptance of m-health app in LMICs. Participants' responses were then grouped and coded according to these themes. The groups of responses were then analysed to determine the common experiences or perceptions amongst the participants (Vaismoradi, Turunen & Bondas, 2013). Themes were compared with the quantitative results to identify factors that should be included in the conceptual framework.

• Domain of empirical	Partial Least Squares (PLS) was used to test the conceptual framework. This method was used to test the UTAUT model (Venkatesh *et al*., 2003). PLS, a second-generation structural equation modelling technique (Hair, Ringle & Sarstedt, 2011), can assess construct validity by estimating the loadings (and weights) of indicators on variables (Lowry & Gaskin, 2014). It also identifies causal relationships among variables. In research, it refers to the acceptance and use of m-health applications and the achievement of diabetes self-management activities. Therefore, this method of analysis is suitable.

3.5 Research validity and reliability

The use of different methods to investigate the same phenomenon will reduce biases such as inquirer bias and "biases of inquiry context" (Greene *et al.*, 1989:259). This research used triangulation as the researcher converged and corroborated results from the quantitative and qualitative methods that were collected in the domain of real and the domain of actual (Cresswell, 2014). The validity of the research will be improved through the use of mixed methods (Golafshani, 2003).

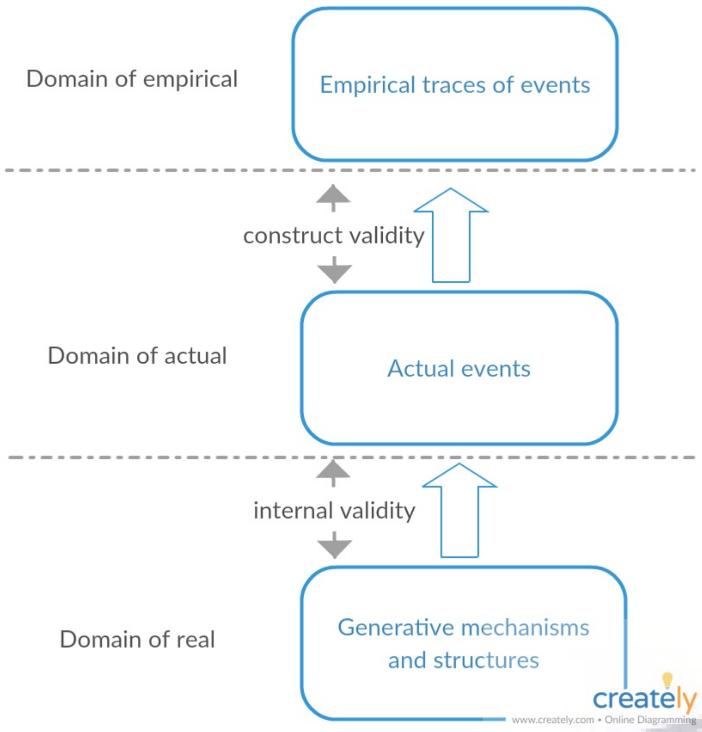


Figure 28 Research validity and critical realism
Adapted from source: Zachariadis, Scott & Barrett (2013)

Validity in quantitative research is the "extent to which an empirical measure adequately reflects the real meaning of the concept under consideration" (Babbie & Mouton, 2001:151).

The measurement validity in the domain of real was achieved as the survey questions were amended from previous studies (Venkatesh *et al.*, 2003). Variables were tested using Cronbach's alpha, average variance extracted and composite reliability to ensure that the measures were reliable, i.e. there was no measurement error (Zachariadis, Scott & Barrett, 2013).

Reliability is the ability of an instrument to measure the underlying variables accurately. The construct reliability and validity of the data needs to be assessed. The values for Cronbach's alpha was used to evaluate the internal consistency of the survey questions (Gliem & Gliem, 2003). A value of 0.6 is an accepted benchmark (Kline, 2013).

Composite reliability, a test of convergent validity, may be preferred to Cronbach's alpha as it may provide better estimates of true reliability (Garson, 2016). As with Cronbach's alpha, the range for composite reliability is between 0 and 1 (Lowry & Gaskin, 2014). The closer the value is to 1, the better the estimated reliability (Garson, 2016). A composite reliability value equal to or greater than 0.7 indicates the model's adequacy for confirmatory purposes (Lowry & Gaskin, 2014).

The average variance extracted (AVE) was used to test convergent and divergent validity. AVE reflects "the average communality for each latent factor in a reflective model" (Garson, 2016:56). AVE measures "the level of variance captured by a construct versus the level due to measurement error" (Alarcón & Sánchez, 2015:5/1). AVE values should exceed 0.5, which indicates that factors "explain at least half the variance of their respective indicators" (Garson, 2016:56).

In critical realism, internal validity is achieved when the actual events (the use or non-use of m-health for diabetes self-management) are indicators of the particular generative mechanisms examined (e.g. access to ICTs) in the Western Cape.

Construct validity ensures that the variables indicate what they are supposed to measure and are consistent with the theoretical description (Zachariadis, Scott & Barrett, 2013). Construct validity was achieved by using factors identified in the domain of actual (using qualitative methods) and the domain of real (using quantitative methods). These variables and literature were used to develop the conceptual framework tested empirically in the domain of empirical.

3.6 Ethical considerations

This research focuses on m-health for development in a health context. It was, therefore, essential to consider ethics when conducting this research (Emanuel, Wendler & Grady, 2000) due to the focus on patients living in low socioeconomic conditions with a condition that potentially leads to morbidity. The research area covered sensitive areas regarding health and socioeconomic conditions. Therefore, as per the recommendations of Dearden and Kleine (2018), the researcher had to be culturally aware, treating respondents with respect. The variables were considered to limit possible risks to respondents, such as the introduction of ICT that respondents found unaffordable.

3.6.1 Ethical practice and oversight

The research was conducted by the ethical and professional guidelines as specified by the University of the Western Cape (UWC). The research was approved by the Senate Research Committee of the University of the Western Cape, registration number 15/7/194. As recommended by Dearden and Kleine (2018), the researcher ensured that the appropriate training and preparation for conducting the research, such as proper interviewing, was completed.

3.6.2 Disclosure and informed consent

The premise of informed consent is to not harm respondents (Sterling & Rangaswamy, 2010). Based on Traxler (2012), the rights and welfare of the human subjects involved in the research were protected. An information sheet regarding the research as well as a consent form were supplied to all potential respondents (Emanuel, Wendler & Grady, 2000). No responses were captured unless consent was first given. Following Dearden and Kleine (2018), respondents had to agree that their responses could be used for research conducted at UWC and publications by the institution.

Based on recommendations by Emanuel, Wendler and Grady (2000), no remuneration was provided, and respondents were able to refuse to answer questions with which they were not comfortable. They also reserved the right to withdraw at any time.

3.6.3 Confidentiality and privacy

No clinical data or unique identifiers (such as names or ID numbers) were collected. Again adhering to Dearden and Kleine (2018), this was to ensure anonymity and protection of the identities and interests of those involved.

3.6.4 Treatment of data

As suggested by Dearden and Kleine (2018), the researcher respected the confidentiality of the data supplied by all involved parties by storing data in a restricted access folder on Google Drive.

3.7 Chapter summary

This chapter discussed research design and methodology with a focus on the three primary paradigms used in IS research. To answer the research questions, a post-positivist paradigm, with a critical realist ontology was selected, with justification for a selection of the paradigm, ontology and methodology highlighted in Table 7. Due to the nature of this research focusing on potentially sensitive health and socioeconomic issues, ethical considerations were imperative.

The subsequent chapter will focus on the domain of real that analysed contextual factors that influence diabetes self-management and the impact on the achievement of developmental goals.

Ramadaan was particularly difficult for me because while most of the students were fasting, I couldn't. I was alone and felt like an outcast, so I tried to fast and almost went into a coma…Years later, I remember shopping at Vangate Mall during Ramadaan to purchase groceries for Iftar (the breaking of the fast) because my husband was fasting. I knew that I was feeling 'funny' and I had bought a bar of chocolate, but the mall was filled with Muslim shoppers, so I felt self-conscious eating the chocolate bar that I needed. My blood sugar level dropped so low that I couldn't remember where I had parked my car and my legs started to go lame. Yet I still did not eat the chocolate! Instead, I got into my car and drove (this is the equivalent of someone drunk driving). I ended up driving round and round the traffic circle and being pulled over by security. Luckily I was driving very slowly (my senses were impaired and my brain was shutting down due to my very low blood glucose). The security asked for my phone and called my husband who then came to fetch me. After finally pulling over I ate the chocolate! I would not consider this my 'normal logical behaviour' but such is my life.

4 Domain of real

As explained previously, the *domain of real,* referring to structures and mechanisms that are endearing, leads to the generation of events (Mingers, 2004). The domain of real is important when investigating a specific contextual situation (Wynn & Williams, 2012). Therefore, this chapter investigated the mechanisms (current level of access to ICTs), structures (current level of diabetes self-management) and events (current use of ICT for diabetes self-management) prevalent in the Western Cape.

While an investigation of risk factors was not included in the original research questions, further literature reviews indicated that this was an important factor in determining the impact on SDGs. Therefore, to identify the contextual factors that influence the use of m-health for diabetes self-management and the impact on the achievement of developmental goals, the research questions were expanded further. Based on Table 3, this was done as follows:

1. **Behaviour –** assess the current level of diabetes self-management (structure);
2. **Risk factors –** analyse the current level of risk factors and resultant diabetes complications (structure);
3. **Intervention –** assess the current level of access to ICTs to indicate whether the necessary mechanisms exist; and
4. **Assess the current use of ICT** – including m-health applications, to identify the mechanisms used for diabetes self-management (event).

Based on Zachariadis, Scott and Barrett (2013), the expansion of research questions is admissible as critical realism accepts the complexity of social research and therefore, "the boundaries of the inquiry may have to be revised as the research process advances" (p.9). To investigate the contextual factors, a representative sample was required.

4.1 Data collection

Data collection took into consideration the type of sampling and the instrument used.

4.1.1 Sampling

This domain used purposive sampling. *Purposive sampling* refers to non-probability sampling and selecting a sample based on a specific purpose (Teddlie & Yu, 2007). In the case of this research, quantitative data was collected from diabetic patients residing in the Western Cape.

The 2018 mid-year population estimates for South Africa by province indicate that the Western Cape population is 6 621 100 (Statistics South Africa, 2018c). With the national diabetes prevalence estimated at 8.39% (Statistics South Africa, 2016), this would equate to a target population of 555 510.29 people with diabetes. The minimum sample size for this population was 384. The minimum sample size was calculated at a 95% confidence interval, using Raosoft online calculator (Raosoft, 2019).

A total of 528 responses were collected in an online survey using field workers. Field workers would ask the survey questions, clarify and explain any questions that were not understood, then capture responses in the online survey. A 6-point Likert scale (from Not At All True to Very True) was used.

After data cleansing, removing responses that had more than 10% missing values and values not all the same (standard deviation=1) (Gaskin, 2016), 497 responses were utilised. This sample size could result in a 4.39% margin of error (Raosoft, 2019).

4.1.2 Instrument

An online survey was used utilising Google forms (refer to section 10.1.2). To answer the expanded research questions above, the survey included sections on:

1. summary of diabetes self-care activities;
2. diabetes complications;
3. access to ICT;
4. user acceptance of ICT and

5. biographical information.

During the administration of the pilot survey, it was found that potential respondents did not have access to the internet, and older respondents were not comfortable using online surveys. It was also found that some respondents who answered the pilot survey did not understand key terms such as ICT or internet access. Therefore, it was decided to have field workers, third-year Information Systems students, collect the data and enter it into the online survey. The use of field workers enhanced reliability of results as they were able to explain key concepts to respondents as well as capture the data accurately.

Field workers were from the B.Com third-year class at the University of the Western Cape, who majored in Information Systems. These students were preferred given that they would have a satisfactory level of digital skill.

The research provided training to familiarise the field workers on the use of the instrument. Further checks were done to ensure that they were adequately prepared. The fieldworkers' role were to collect data due to the extensive data collection a team was necessary.

The risk of bias by using students as field workers was reduced through the use of structured instruments. Field workers were conversant in the language of their respondents.

4.1.3 Data analysis

Given the reliability of the variables, the data were used for analysis. *Data* is defined as one of the following:

- Categorical (qualitative):
  - *Nominal* – this variable has more than two categories, mutually exclusive and unordered, for example, black, white, coloured and others, as it does not matter in which order each variable is placed. Gender is an example of this type of variable.
  - *Ordinal* - this variable has more than two categories, mutually exclusive and ordered, for example, a 5-point scale, typically a Likert scale (Diez, 2012).

Because the variables being predominantly ordinal (0-7 days), data were analysed using descriptive statistics in the SPSS software tool.

4.2 Findings

The findings commence with demographic analysis, determining the current level of diabetes self-management, the current level of access to ICTs and concludes with the analysis of the use of ICT for diabetes self-management.

4.2.1 Demographics

Table 8 provides a general overview of the 497 Western Cape respondents who participated in this research. The majority of respondents were female older than 50 who had type 2 diabetes, using oral medication. The highest percentage of respondents spoke English (43.4%) followed by Xhosa (27.7%) and Afrikaans (23.1%).

The majority of respondents (33.2%) have Grade 12 as their highest level of education. However, 23.7% have only partial high schooling, with 37.9% of respondents earning less than R2 500 (approximately $180) per month.

The racial profile of respondents included the majority being coloured (54.5%) followed by black (33.2%) South Africans. This aligns with previous studies describing these populations like those with the highest rates of diabetes in the Western Cape (Erasmus *et al.*, 2012).

Table 8 Demographic information of respondents

			Frequency	Per cent
GENDER	Valid		4	.8
		Female	278	55.9
		Male	215	43.3
		Total	497	100.0
AGE	Valid		1	.2
		16 - 24 years	53	10.7
		25 - 34 years	107	21.5
		35 - 49 years	134	27.0
		older than 50 years	202	40.6
		Total	**497**	**100.0**
TYPE OF DIABETES	Valid		5	1.0
		Gestational diabetes - diabetes during pregnancy	2	.4

		Latent autoimmune diabetes of adults (LADA) - Type 1 insulin-dependent diabetes (diagnosed in adults, when older)	14	2.8
		Prediabetic	4	.8
		Type 1 - juvenile-onset (diagnosed when young), insulin-dependent	29	5.8
		Type 2 - insulin resistant, using oral diabetes medication, e.g. metformin, Glucophage	242	48.7
		Type 2 - using oral diabetes medication and insulin	201	40.4
		Total	**497**	**100.0**
HIGHEST EDUCATIONAL LEVEL	Valid		3	.6
		Diploma or Certificate	76	15.3
		Matric (Grade 12) - Senior Certificate	165	33.2
		No schooling	4	.8
		Primary school	31	6.2
		Some high schooling	118	23.7
		Some primary schooling	28	5.6
		Technikon	14	2.8
		University Degree	58	11.7
		Total	**497**	**100.0**

The top five communities in which the respondents reside include Mitchell’s Plain (11.4%), Belhar (10.8%), Khayelitsha (9.4%), Athlone (6.0%), Delft and Gugulethu (4.6%). These areas are regarded as low socioeconomic communities within the Western Cape (Figure 29). This aligns to low socioeconomic communities because, as stated previously, approximately 63% of households in Khayelitsha and Mitchell’s Plain have incomes of less than R4 166 per month (approximately $296), of which 16.5% have no income (Western Cape Government, 2017a).

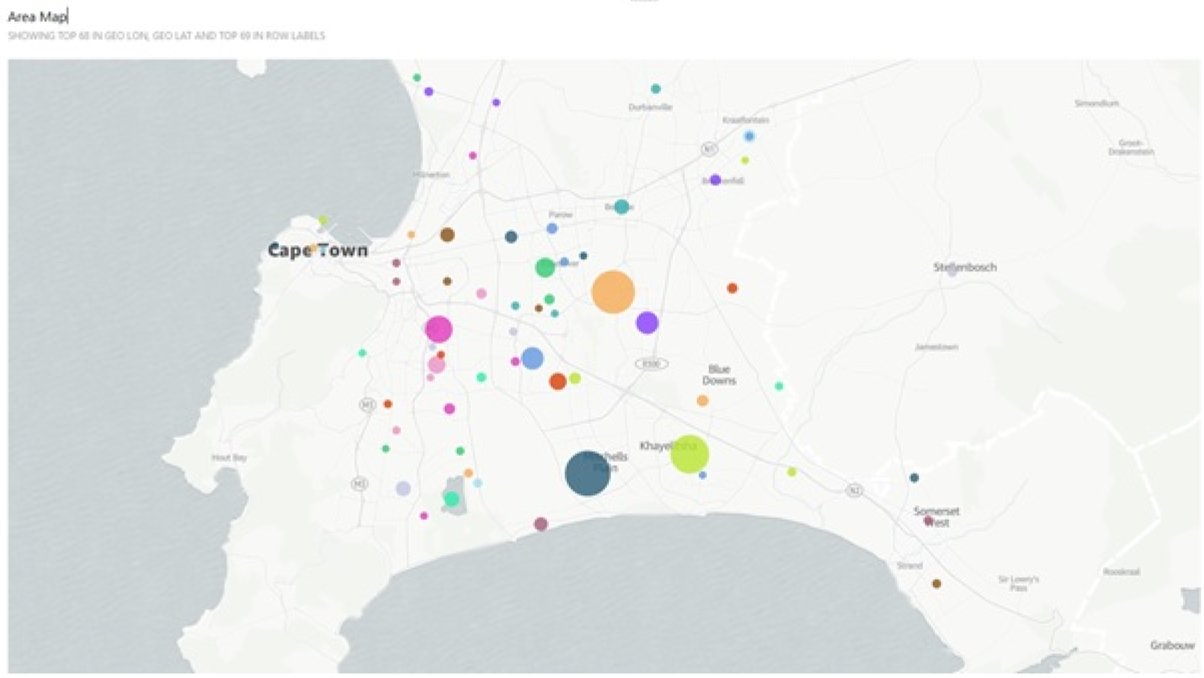


Figure 29 Heat map of respondents' areas

4.3 Current level of diabetes self-management: investigating structures

As stated in the literature review, the achievement of developmental goals is determined by the level of diabetes self-management activities performed. To assess the level of diabetes self-management, the Summary of Diabetes Care Activities (SDCA) was selected because it was validated and tested on a sample of almost 2000 respondents (Toobert, Hampson & Glasgow, 2000). The justification for using the Summary of Diabetes Care Activities was highlighted in Table 6 Comparison between self-management assessment tools.

At the completion of this part of this research, there was no research on the level of diabetes self-management in South Africa using the SDCA. Therefore, it was necessary to investigate the structures to determine whether or not there is a need to use m-health for diabetes self-management, as this could not be assumed. Subsequently, research has indicated low levels of diabetes self-management in sub-Saharan Africa (Stephani, Opoku & Beran, 2018), so a need was identified for undertaking this research.

4.3.1 Instrument

Based on section 3.4.2, the Diabetes Summary of Care Activities was used to achieve the objective of determining the current level of diabetes self-management.

4.3.2 Reliability

To test the reliability of the measure, Cronbach's alpha coefficient was calculated to ensure internal consistency. According to Gliem and Gliem (2003), the closer Cronbach’s alpha coefficient is to 1.0, the greater the internal consistency of the items in the scale, with a measure of 0.7 being the benchmark of acceptance. However, another author insists that a Cronbach's alpha coefficient between 0.6 and 0.7 is also acceptable (Kline, 2013).

The initial Cronbach's alpha coefficient results indicated that only blood sugar testing, foot care and exercise met the accepted measure of acceptance of 0.6. Item total statistics were run to determine which question was lowering the Cronbach's coefficient alphas. In the Diet section, it was found that if the question ‘On how many of the last seven days did you eat five or more servings of fruits and vegetables?’ were deleted, then the Cronbach's coefficient alphas would increase from 0.523 to the acceptable benchmark of 0.755.

The initial Cronbach's coefficient alpha for medication was 0.413 but it was found that if the question ‘OR - On how many of the last seven days did you take your recommended insulin injections?’ were deleted, then the Cronbach's coefficient alphas would increase to the benchmark of acceptance of 0.694. This was possibly due to not all respondents using insulin.

After adjustments were made, all variables in Table 9 reached an acceptable level of reliability. This is based on Cronbach's coefficient alphas being greater than 0.6, based on Kline (2013).

Table 9 Cronbach’s alpha reliability results for the summary of diabetes care activities

VARIABLES	CRONBACH'S ALPHA	NUMBER OF ITEMS	RESULTS
Diet	.755	4	Accepted
Exercise	.701	2	Accepted
Foot care	.629	5	Accepted
Medication	.694	2	Accepted
Blood glucose testing	.899	2	Accepted

4.4 Current level of diabetes self-management

The findings are based on analysis of the summary of diabetes self-care activities to indicate the current level of diabetes self-management. Moreover, the risk factors and the resultant impact on diabetes complications were analysed to determine the impact of developmental goals.

4.4.1 Summary of diabetes care activities

Respondents indicated that they took their recommended diabetes medication on average 5.60 times in a week, as evident in Table 10. This was the third-highest mean, so it demonstrates that most respondents are taking their medication, although it is not at the required level of taking it daily. Also, they did not take the medicine at the recommended dosage (mean=5.27), which could be detrimental to their health and well-being. It is also probably a key indicator for the high level of diabetes complications (refer to Table 14).

The level of blood sugar testing had an average of 3.20. It was evident that the level of blood sugar testing recommended by health care providers was higher, as the mean was the lowest of all activities (2.26). It is indicated that three to five tests per week for patients who use oral diabetes medication (48.7% of respondents in this study) should be adequate, based on Amod *et al.* (2012). Patient education is highlighted as a key factor because patients need to understand their glycaemic targets as well as know what to do if these are not being met (Amod *et al.*, 2012).

Respondents indicated that they follow a healthy diet for almost half of the week (3.47 days). The washing (6.59) and drying of the feet (6.16), especially between the toes, were rated as the activities performed the most. Participating in a specific exercise session was ranked as the activity least performed (2.26). These results indicate that the risk factors associated with physical inactivity are high for this group.

Table 10 Summary of diabetes care activities

	SURVEY QUESTIONS	N	MEAN	STD. DEVIATION	SUBSET MEAN	SUBSET STD. DEVIATION
DIET	How many of the last SEVEN DAYS have you followed a healthful eating plan?	496	3.88	2.207	3.47	2.085

	On average, over the past month, how many DAYS PER WEEK have you followed your eating plan?	491	3.87	2.076		
	On how many of the last SEVEN DAYS did you eat high-fat foods such as red meat or full-fat dairy products?	489	3.17	1.907		
	On how many of the last SEVEN DAYS did you space carbohydrates evenly through the day?	483	2.95	2.151		
EXERCISE	On how many of the last SEVEN DAYS did you participate in at least 30 minutes of physical activity? (Total minutes of continuous activity, including walking).	492	3.26	2.464	**2.76**	2.402
	On how many of the last SEVEN DAYS did you participate in a specific exercise session (such as swimming, walking, biking) other than what you do around the house or as part of your work?	491	2.26	2.340		
BLOOD GLUCOSE TESTING	On how many of the last SEVEN DAYS did you test your blood sugar?	491	3.35	2.652	3.20	2.633
	On how many of the last SEVEN DAYS did you test your blood sugar the number of times recommended by your health care provider?	490	3.05	2.614		
FOOT CARE	On how many of the last SEVEN DAYS did you check your feet?	483	3.98	2.777	4.43	2.264
	On how many of the last SEVEN DAYS did you inspect the inside of your shoes?	489	2.57	2.712		
	On how many of the last SEVEN DAYS did you wash your feet?	487	**6.59**	1.335		
	On how many of the last SEVEN DAYS did you soak your feet?	484	2.86	2.648		
	On how many of the last SEVEN DAYS did you dry between your toes after washing?	486	6.16	1.850		
MEDICATION	On how many of the last SEVEN DAYS, did you take your recommended diabetes medication?	490	5.60	2.321	4.77	2.721

	OR - On how many of the last SEVEN DAYS did you take your recommended insulin injections?	417	3.44	3.213		
	On how many of the last SEVEN DAYS did you take your recommended number of diabetes pills?	474	5.27	2.630		
	Valid N (listwise)	347				

To assess the overall impact of the self-management activities or the lack thereof, a Glycated haemoglobin (HbA1c) test can be performed. The "HbA1c reflects average plasma glucose over the previous eight to 12 weeks" (World Health Organization, 2011:6).

If a patient's HbA1c is within the target (less than 7% for the majority of patients) and treatment has not been changed, it is recommended that HbA1c levels be checked every six months (Amod *et al*., 2012). Table 11 indicates that more than half of the sample population (57.3%) tested their HbA1c levels, yet the highest percentage (30.2%) did not know whether there were any changes in their levels, as evident in Table 12.

Table 11 HbA1C tested in the last six months

Have you tested your HbA1C levels in the last six months?

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid		24	4.8	4.8	4.8
	I don't know	108	21.7	21.7	26.6
	No	80	16.1	16.1	42.7
	Yes	285	57.3	57.3	100.0
	Total	497	100.0	100.0	

Evidence indicates that 26.6% of respondents had no change in their HbA1c readings, possibly due to results not being presented or explained to patients, coupled with changes in treatment that will assist in improving their HbA1c readings (refer to Table 12).

Table 12 Changes to HbA1c results

If you have tested your HbA1c levels in the last six months, how have your HbA1C levels changed since your last test?

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid		76	15.3	15.3	15.3

Decreased	92	18.5	18.5	33.8
I don't know	150	30.2	30.2	64.0
Increased	47	9.5	9.5	73.4
No change	132	26.6	26.6	100.0
Total	497	100.0	100.0	

Research indicates that patients who know their HbA1c values "reported a better understanding of diabetes self-management and assessment of their glycaemic control as compared to respondents who did not know their HbA1c values" (Nam *et al.*, 2011:3).

4.4.2 Risk factors

Risk factors highlighted in the literature included an unhealthy diet, physical inactivity and tobacco use (Rehman *et al.*, 2017). As the previous section already included the analysis for exercise and diet, smoking was analysed next.

More than half of the respondents last smoked more than two years ago or have never smoked. However, 21.7% indicated that they had smoked on that day, as seen in Table 13.

Table 13 Smoking frequency

When did you last smoke a cigarette?

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid		98	19.7	19.7	19.7
	Four to eleven months ago	8	1.6	1.6	21.3
	More than two years ago, or never smoked	257	51.7	51.7	73.0
	One to three months ago	3	.6	.6	73.6
	One to two years ago	12	2.4	2.4	76.1
	Today	108	21.7	21.7	97.8
	Within the last month	11	2.2	2.2	100.0
	Total	497	100.0	100.0	

However, it appears that while many patients are asked about their smoking status (50.9%), 47.1% of them were not. For the ones sho smoked, 17.5% indicated that they were counselled about smoking cessation or referred to a stop-smoking programme. This bodes well in reducing smoking as a risk factor.

4.4.3 Diabetes complications

To assess the impact of the lack of self-management activities and risk factors indicated above, the level and nature of diabetes complications were also analysed. More than half of the respondents indicated that they had diabetes complications, as evident from Table 14.

Table 14 Diabetes complications

Have you ever had diabetes complications?

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid		3	.6	.6	.6
	No	243	48.9	48.9	49.5
	Yes	251	**50.5**	50.5	100.0
	Total	497	100.0	100.0	

Despite the high number of respondents who indicated they had suffered diabetes complications, only 26.4% responded that they were admitted to the hospital (see Table 15).

Table 15 Hospital admissions due to diabetes complications

Have you ever been admitted to the hospital due to your diabetes? If yes, please complete the next question

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid		38	7.6	7.6	7.6
	No	328	**66.0**	66.0	73.6
	Yes	131	26.4	26.4	100.0
	Total	497	100.0	100.0	

The majority of hospital admissions occurred less than four years ago, as clear from Table 16. However, this could potentially have a negative effect on achieving SDG, NCD and NDP goals due to the number of admissions being included in the national objectives as indicators for chronic diseases.

Table 16 Date of hospital admissions

When were you admitted?

	Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	333	67.0	67.0	67.0

		Frequency	Per cent	Valid Percent	Cumulative Percent
	between 1 and 3 years ago	60	12.1	12.1	79.1
	I can't remember	22	4.4	4.4	83.5
	I get admitted numerous times each year	4	.8	.8	84.3
	less than 1 year ago	47	9.5	9.5	93.8
	more than 3 years ago	31	6.2	6.2	100.0
	Total	497	100.0	100.0	

Hospital admissions also mean an increased health burden as they are indicative of poor diabetes self-management.

4.5 Current access to ICTs: Investigating mechanisms

The use of ICT can facilitate diabetes self-management and lower risk factors. Therefore, it was essential to assess the current level of access to ICTs insufficient ICT access may negatively impact the ability to use m-health applications.

4.5.1 Data analysis

As variables were ordinal (Diez, 2012), the section related to ICT access in the online survey was analysed using descriptive statistics in SPSS software (Diez, 2012).

4.5.2 Current level of access to ICTs

The majority of respondents (37.4%) use prepaid air time to access the internet on mobile phones, followed by 23.1% of respondents who rely on Wi-Fi. The additional places provided, not indicated on the survey, were obtained from the respondents who provided feedback under the option **'Other'** on the survey. It is important to note that 15.7% of respondents indicated that they do not have internet connectivity or did not use a cell phone, as presented in Table 17, which could impact on the use of m-health apps for diabetes self-management.

Table 17 Internet access

How do you connect to the internet?

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid		8	1.6	1.6	1.6
	work	1	.2	.2	1.8
	At a friend's house	1	.2	.2	2.0
	At a public institution e.g. public library	13	2.6	2.6	4.6

	Cell phone - Contract	38	7.6	7.6	12.3
	Cell phone - Prepaid	186	37.4	37.4	49.7
	Coffee Shop	1	.2	.2	49.9
	Does not use the cell phone	1	.2	.2	50.1
	I don't have internet connectivity	77	15.5	15.5	65.6
	I don't worry with the internet.	1	.2	.2	65.8
	I have access to it on my phone; I just don't know how to use it.	1	.2	.2	66.0
	I never use the internet	1	.2	.2	66.2
	Internet at work	1	.2	.2	66.4
	Internet cafe	4	.8	.8	67.2
	Land line - ADSL	40	8.0	8.0	75.3
	library	2	.4	.4	75.7
	Not computer literate	1	.2	.2	75.9
	Not interested	1	.2	.2	76.1
	The interviewee said that he generally connects to the internet at the nearest hotspots.	1	.2	.2	76.3
	The interviewee said that he sometimes uses his laptop.	1	.2	.2	76.5
	Too lazy to understand	1	.2	.2	76.7
	Wi-Fi	115	23.1	23.1	99.8
	All of the above	1	.2	.2	100.0
	Total	497	100.0	100.0	

Therefore, despite South Africa's ICT and related policies to enhance inclusive growth and development through the provision of universal access, irrespective of geography and social status, this does not appear to have materialised.

It was also noted, although this was not a significant percentage, five respondents (1%) did not use a cell phone, were not interested in using the internet or were too lazy to understand. This refers to respondents' attitude towards use. Dwivedi *et al.* (2017) highlighted that attitude towards use has a direct effect on use, as indicated in the Technology Acceptance Model. Therefore, a negative attitude towards use could negatively impact the use of m-health for diabetes self-management.

Data were also analysed to determine the frequency of technology use (see Table 18) as low technology usage and engagement are potential barriers to m-health use (Venkatesh *et al.*, 2003; Simblett *et al.*, 2018).

Table 18 Frequency of use

How often do you use the technology you have?

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid		127	25.6	25.6	25.6
	Every day	157	31.6	31.6	57.1
	Few times a month	29	5.8	5.8	63.0
	Never	92	18.5	18.5	81.5
	Very seldom	40	8.0	8.0	89.5
	Weekly	52	10.5	10.5	100.0
	Total	497	100.0	100.0	

The highest percentage of respondents (31.6%) indicated they use technology daily, but the semi-structured interviews in the domain of actual revealed that internet usage was for social media such as Facebook and WhatsApp and not m-health or health-related activities (section 5.3.3.4). However, results indicated that 18.5% of respondents never use technology. This will be a barrier to m-health app acceptance and use.

4.6 Current use of ICT for diabetes self-management: Investigating events

Literature indicated a dearth of evidence concerning the likely uptake or best strategies for engagement, efficacy or effectiveness. Therefore, additional research into context and structure affecting the acceptance and use of m-health applications for diabetes self-management, where usage remains low among, is required (section 2.6).

Research indicates that the acceptance and use of ICT and m-health specifically can assist in achieving health outcomes (Rehman *et al.*, 2017). However, there are disparities in usage (Nelson, Mulvaney *et al.*, 2016). As explained in 2.4.9 above, the MultiTAU model (Venkatesh, Thong & Xu, 2016) includes a baseline model with key determinants of intention and use from the UTAUT and UTAUT2 models. The shared variables in the UTAUT and UTAUT2 model (performance expectancy, effort expectancy, social influence and facilitating conditions) served as a theoretical basis to determine whether or not the ICT was being used for diabetes self-management, thereby confirming the critical realism event.

4.6.1.1 Data analysis

Data were analysed using Partial Least Squares (PLS) utilising the tool, Smart PLS3 (Ringle, Wende & Becker, 2015). The PLS technique was used to test the hypotheses due to several advantages, according to Hair, Ringle and Sarstedt (2011):

1. It is a second-generation structural equation modelling technique so it can estimate the loadings (and weights) of indicators on variables, thereby ensuring construct validity;
2. It can be applied to smaller samples; and
3. It can assess the causal relationships among variables in multistage models.

PLS-SEM is a non-parametric method, meaning that data does not need to be normally distributed. Therefore, the Shapiro-Wilk test to determine normality was not run in SPSS software (Ghasemi & Zahediasl, 2012). Additionally, PLS-SEM was used by Venkatesh *et al.* (2003) to test the UTAUT model. Therefore, PLS-SEM was found suitable to test these hypotheses using Smart PLS 3 software (Ringle, Wende & Becker, 2015).

A PLS-SEM path coefficients test was run to assess the strength and direction of the relationship between the variables as defined in the hypotheses (Huang *et al.*, 2013). A positive influence is indicated by a positive path coefficient. Alternatively, a negative path coefficient presents a negative influence.

R^2, providing a model of fit measure (Garson, 2016) predicts which value of the dependent variables can be explained by the independent variables. The variance in the percentage is representatives of the predictive power of the research model, its values ranging between 0 and 1: the larger the value, the better the explanatory power of the model (Diez, 2012). Based on Chin, Marcolin and Newsted (2003), R^2 higher than 0.67 represents a good explanatory power; R^2 between 0.33 and 0.66 represents a moderator explanatory power, and R^2 between 0.19 and 0.33 represents a weak explanatory power.

The significance of the results, such as Cronbach's alpha, path coefficients and R^2, are generated by a bootstrap procedure. According to Hair *et al.* (2017:304), *bootstrapping* "is a resampling technique that draws a large number of subsamples from the original data (with replacement) and estimates models for each subsample. It is used to determine standard errors of coefficients to assess their statistical significance without relying on distributional assumptions". The number of subsamples must be large to ensure the stability of results. Therefore, based on Hair *et al.* (2017), a bootstrap subsamples of 5000 was used for the preparation of the final results.

In this study, the p-value, generated by bootstrapping, was used to test the hypotheses following the process advocated by Hair *et al.* (2017). R^2, as per Garson (2016), was used to determine the predictive power of the conceptual framework.

4.6.1.2 Construct reliability and validity

As stated previously, *reliability* is the ability of an instrument to measure the underlying variables accurately. The construct reliability and validity of the data were assessed first (refer to Table 19). Based on Gliem and Gliem (2003), the values for Cronbach's alpha were applied to evaluate the internal consistency of the survey questions, with a value of 0.6 is an accepted benchmark (Kline, 2013). The internal consistency of all variables meets the level of acceptance, as they were higher than 0.8.

Table 19 ICT usage construct reliability and validity results

	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Behavioural Intention	0,959	0,974	0,925
Effort Expectancy	0,960	0,971	0,893
Facilitating Conditions	0,819	0,880	0,650
Performance Expectancy	0,890	0,924	0,753
Social Influence	0,820	0,881	0,650

Composite reliability, a test of convergent validity, may be preferred to Cronbach's alpha as it may provide closer estimates of true reliability (Garson, 2016). As with Cronbach's alpha, the range for composite reliability is between 0 and 1 (Lowry & Gaskin, 2014). The closer the value is to 1, the better the estimated reliability (Garson, 2016). A composite reliability value equal to or greater than 0.7 means that the model is adequate for confirmatory purposes (Lowry & Gaskin, 2014). Given that the values for composite reliability are all greater than 0.8 (refer to Table 19), the model is suitable for confirmatory research (Garson, 2016).

The average variance extracted (AVE) was used to test convergent and divergent validity. AVE reflects "the average communality for each latent factor in a reflective model" (Garson, 2016:56). AVE measures "the level of variance captured by a construct versus the level due to measurement error" (Alarcón & Sánchez, 2015:5/1). AVE values should exceed 0.5, indicating that factors "explain at least half the variance of their respective indicators" (Garson, 2016:56). All AVE values were greater than 0.6; therefore; the conditions have been met.

4.6.2 Discriminant validity

Discriminant validity is required to prevent multicollinearity issues. *Multicollinearity* refers to the existence of high inter-correlations among independent variables (Ab Hamid *et al.*, 2017). The PLS correlation coefficient matrix was used in this study to assess discriminant validity.

According to Gaski and Nevin (1985), there are two criteria to test discriminant validity: that the correlation coefficient between the two variables must be less than 1, and that the correlation coefficient of the two variables must be less than the individual Cronbach's alpha. Data in Table 20 show the correlation coefficient of the two variables was less than 1. Also, the correlation coefficient of the two variables was less than the individual Cronbach's alpha. Based on Fornell and Larcker (1981), discriminant validity can also be determined by comparing the square root of the average variance extracted. In Table 20, the square root of the average variance is represented by diagonal values. According to Lowry and Gaskin (2014:27), the diagonal elements must be greater than the off-diagonal elements for the same row and column, not the AVE value itself. The diagonal values in Table 20 are higher than any other correlation. Therefore, all criteria for discriminant validity were satisfied.

Table 20 ICT usage correlation coefficient matrix

	Behavioural Intention	Effort Expectancy	Facilitating Conditions	Performance Expectancy	Social Influence
Behavioural Intention	**0,962**				
Effort Expectancy	0,635	**0,945**			
Facilitating Conditions	0,641	0,787	**0,806**		
Performance Expectancy	0,587	0,674	0,662	**0,868**	
Social Influence	0,571	0,557	0,609	0,583	**0,806**

Given that the data meet the criteria for construct reliability and validity as well as discriminant validity, it was used to test the hypotheses.

4.6.3 Hypotheses

The behavioural intention was examined as the main objective to identify factors related to technology acceptance and use for diabetes self-management. As shown by Venkatesh *et al.* (2016), behavioural intention has a direct influence on the usage of technology. Use behaviour, the independent variable in the MultiTAU model, will be examined in section 6.

Based on Venkatesh *et al.* (2016), the four key shared variables identified in the MultiTAU model were tested, with the relationship between the variables hypothesised in Table 21.

Table 21 Current use of ICT for diabetes self-management hypotheses

No	HYPOTHESES
H1	Performance expectancy will have a positive influence on behavioural intention to use ICT for diabetes self-management
H2	Effort expectancy will have a positive influence on behavioural intention to use ICT for diabetes self-management
H3	Social Influence will have a positive influence on behavioural intention to use ICT for diabetes self-management
H4	Facilitating conditions will have a significant influence on behavioural intention to use ICT for diabetes self-management.

This is also graphically illustrated in Figure 30.

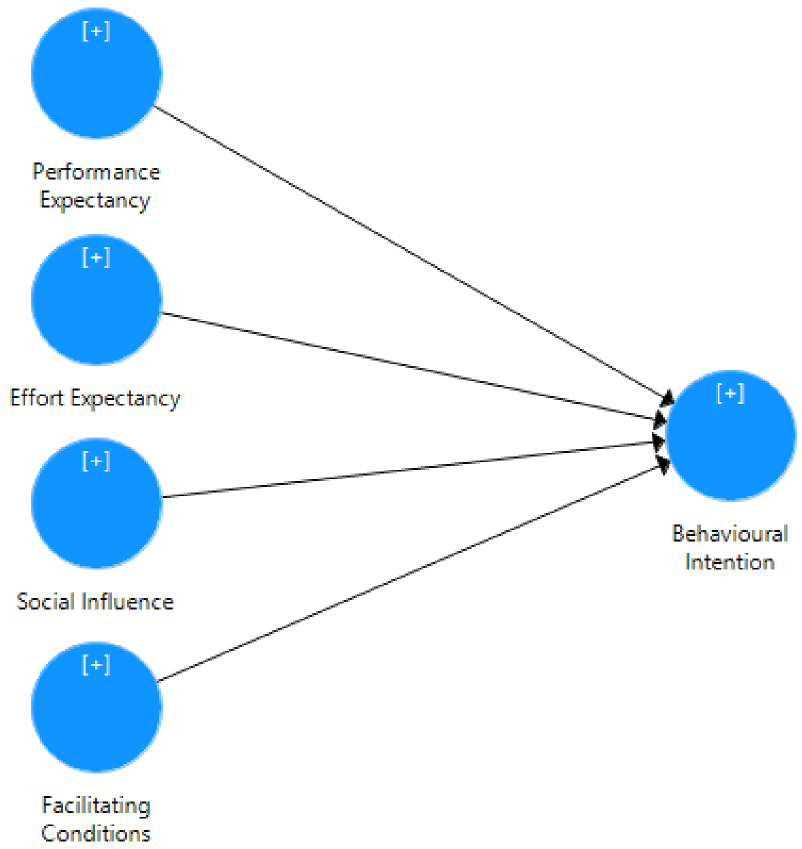


Figure 30 Current use of ICT for diabetes self-management hypotheses

4.6.4 Current use of ICT for diabetes self-management

The testing of hypotheses aims to determine which independent variables provide a meaningful contribution to the explanation of the dependent variables (Alshehri, Drew & AlGhamdi, 2013). According to Hair *et al.* (2016), a path coefficient compares the strength of the effect of each independent variable on the dependent variables. The higher the absolute value of the path coefficient, the stronger the effect. This is graphically illustrated in a path coefficient model (refer to Figure 31).

Figure 31 illustrates that effort expectancy has the strongest effect (0.235) on BI, followed by facilitating conditions (0.222). R-squared (R^2) predicts which value of the dependent variables can be explained by the independent variables. The variance in the percentage represents the predictive power of the research model, its values ranging between 0 and 1. The larger the value, the better the explanatory power of the model (Diez, 2012). Therefore, R^2 indicates a moderate explanatory power of 50.6%, as seen in Figure 31. Therefore, the inclusion of higher-level and individual-level contextual factors may improve the explanatory power.

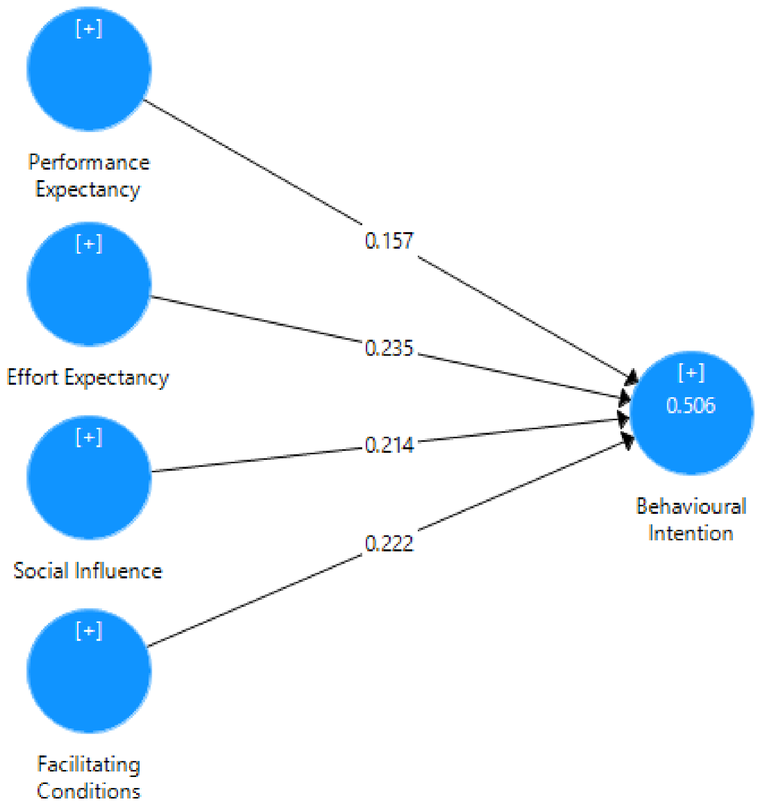


Figure 31 Hypotheses path coefficients

The next phase assessed the research model by testing the hypotheses using the bootstrapping method. The results in Table 22 indicated that the relationships between all four variables and behavioural intention were statistically significant (p-value < 0.05).

Table 22 Hypotheses testing results

Hypothesis		Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P values	Results
H1	Effort Expectancy -> Behavioural Intention	0,235	0,232	0,066	3,588	0,000	Accept
H2	Facilitating Conditions -> Behavioural Intention	0,222	0,226	0,066	3,346	0,001	Accept
H3	Performance	0,157	0,155	0,057	2,759	0,006	Accept

	Expectancy -> Behavioural Intention						
H4	Social Influence -> Behavioural Intention	0,214	0,215	0,049	4,338	0,000	Accept

Therefore, all four hypotheses were supported, as graphically illustrated in Figure 32.

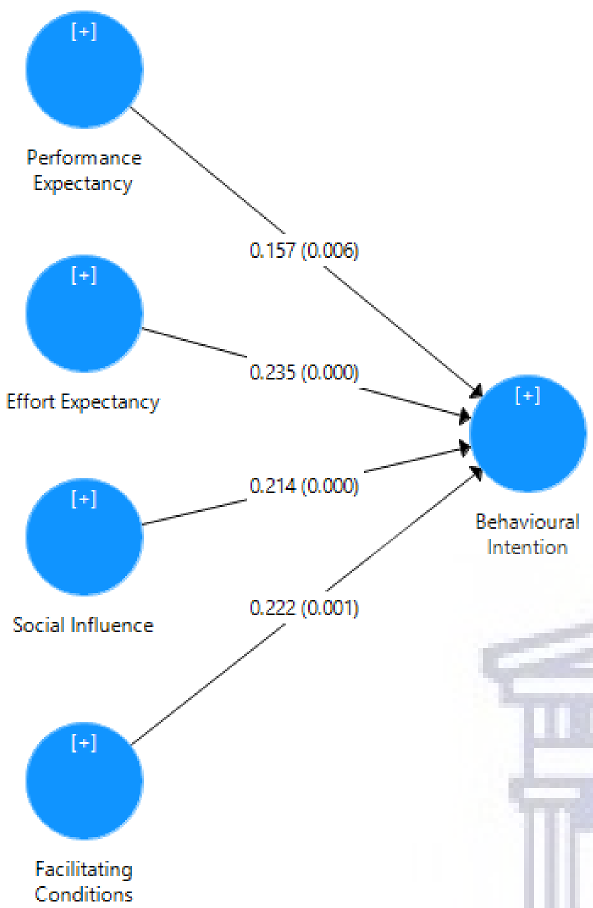


Figure 32 Current use of ICT for diabetes self-management hypotheses p values

As the results reveal, performance expectancy, effort expectancy, facilitating conditions and social influence all had a positive influence on behavioural intention to use ICT for diabetes self-management. Also, effort expectancy had the most significant influence on behavioural intention. The results of the study confirm that all four shared independent variables inherent in the UTAUT and UTAUT2 models explain the factors that affect ICT acceptance amongst diabetic patients.

Additionally, to identify other mechanisms used, 42.7% of respondents indicated that they have glucose meters. And more than half the respondents (51.9%) who had glucose meters used an Accu-check brand. One respondent mentioned that his Accu-chek meter was state-issued which is likely the reason for the high preference. Research indicates that glucose meters, such as the Accu-Chek Performa Connect Smart meter, connect to a compatible mobile device (Accu-Chek, 2017). The Accu-Chek Performa Connect diabetes management system achieved high accuracy (Parkin, Homberg & Hinzmann, 2015), consequently facilitating better decisions through improved connectivity.

Computer reports integrated into the user and healthcare web portals enable patients and their health care teams to "identify and utilize key diabetes information with significantly greater accuracy and efficiency compared with traditional logbook information" (Parkin *et al.*, 2015:833). Despite this research, Table 23 indicates that 28.6% of respondents indicated that they did not download reports with readings from their devices. This, however, is linked to 20% of respondents not having the skills to complete the tasks or having glucose meters without that functionality.

Table 23 Glucose meter functionality

If you have a glucose meter - do you download your readings?

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid		179	36.0	36.0	36.0
	I don't know how to	53	10.7	10.7	46.7
	My glucose meter can't do that	46	9.3	9.3	55.9
	No	142	**28.6**	28.6	84.5
	Yes	77	15.5	15.5	100.0
	Total	497	100.0	100.0	

Research indicates that "patient satisfaction with these types of technologies is high and correlated strongly with ease of use and improved diabetes management" (Parkin *et al.*, 2015:833).

Although there is also strong support in the literature that behavioural intention is a strong indicator of use behaviour, in this study, almost 70% of the respondents indicated they do not use ICT such as m-health applications to manage their diabetes. This is made evident in Table 24.

Table 24 Technology used to manage diabetes

Do you use any other technology to help you manage your diabetes, e.g. diabetes application on your smartphone, insulin pump, continuous glucose monitoring (CGM)

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid		42	8.5	8.5	8.5
	I don't know	24	4.8	4.8	13.3
	No	335	**67.4**	67.4	80.7
	Yes	96	19.3	19.3	100.0
	Total	497	100.0	100.0	

These factors were probed further in the next phase of the study which involved the analysis of qualitative data to understand in granular detail the contextual issues which underpin the low levels of m-health use.

4.7 Chapter summary

This chapter analysed the context in which patients with diabetes live in the Western Cape. Results indicated that the level of self-management activities are low. ICT, such as m-health applications on Smartphones, are used by less than 30% of respondents. Preference is given to the use of glucose testing machines, yet many respondents don't test the required number of times specified by their health care team or download their glucose readings. This could result in respondents suffering from diabetes complications. Therefore, there is a negative impact on the achievement of SDGs and other policies such as NDP 2030, given that diabetes complications could result in morbidity and mortality.

The next phase involved an investigation of the challenges such as higher-level contextual factors and individual-level contextual factors.

<u>**CHAPTER 5 – Domain of actual**</u>

When I was at primary school, I remember spending half my school day alone at Red Cross hospital. When pagers became available and my dad had to rush off to work, I could send my dad a message to collect me from the hospital and wait until he arrived. I would use glucose testing strips that required me to use a timer and check the result on the side of the testing strips bottle. We did not have medical aid, so I did not have a glucose testing machine that showed my blood glucose reading until I participated in a study that gave me one for free; and testing strips, too. My mom-in-law and many of my family members have uncontrolled type 2 diabetes, too. Most of my family is not able to afford medical aid. I received an SMS from my aunt earlier today to ask if I had a glucose testing machine for my cousin's husband who was admitted to hospital due to high blood glucose levels. They also don't have medical aid and cannot afford to buy a testing machine for him even though he's developing diabetes complications. Your money or your life?

5 Domain of actual

The events and non-events in the domain of actual are created by mechanisms and structures in the domain of real. In this study, the domain of real and literature provided the basis for understanding the challenges contributing to the inadequate usage of m-health apps for diabetes self-management. This chapter answered the research sub-question: ***What are the challenges for the acceptance and use of m-health apps for diabetes self-management?***

The inclusion of this question is supported by the finding in the domain of real that behavioural intention did not translate into use. This question is supported by the fact that almost 70% of respondents did not use forms of ICT, such as m-health, for their diabetes self-management. As a next step, it was, therefore, important to probe the contextual issues in relation to m-health app acceptance and use. As the findings in the previous chapter indicated that there was a moderate explanation of BI, this chapter delves into challenges to improve the understanding of reasons for low levels of diabetes self-management (structure) and why access to ICT (mechanisms) did not translate into the use of m-health apps (event) from the perspective of the patient experience.

The chapter is organised as follows: it commences with a description of the research instrument, data analysis and findings. It concludes with the triangulation of quantitative findings from the domain of real in the previous chapter, and the qualitative findings from this chapter.

5.1 Data collection

This section covers the sampling method, the instrument used and data analysis.

5.1.1 Sampling

Due to time and budgetary constraints, it was not possible to interview all 497 respondents participating in the domain of real. Therefore, this section of the research used random sampling from the purposively sampled respondents surveyed in section 4. According to Teddlie and Yu (2007), random sampling occurs when each sampling unit in a clearly defined population, i.e. patients with diabetes residing in the Western Cape who completed the online survey, had an equal chance of inclusion in the sample. Qualitative data were collected from semi-structured interviews with 131 (26%) respondents who participated in the domain of real.

5.1.2 Instrument

This part of the study used a semi-structured interview as semi-structured interviews allows respondent responses to be probed beyond the prepared interview questions.

The interview questions in the interview guide were based on a combination of common themes related to diabetes self-management, technology acceptance and use (refer to 10.2.2). Questions were designed to explore diabetic patients' experiences regarding the use of ICT, including m-health apps, for diabetes self-management. The interview consisted of open-ended questions which probed challenges identified in section 2.5, such as higher-level and individual-level contextual factors to more clearly understand patient perceptions of technology regarding acceptance and use at a more granular level. It also provided insight into whether or not other mechanisms for diabetes self-management were used in this context. Interviews were recorded using voice recorders and then transcribed into a Word processor.

5.2 Data analysis

Qualitative analysis is described as a method for the researcher to gain insight in understanding underlying reasons, perceptions and motivations (Sutton & Austin, 2015) as well as consequences that emerge as a result of the interrelationships between conditions and actions (Strauss & Corbin, 2008). This phase of the study was qualitative and explorative as it gathered an understanding of the perceptions and challenges experienced by diabetic patients.

This study used thematic analysis to identify common challenges related to the acceptance and use of m-health apps for diabetes self-management. Thematic analysis, aiming to identify common areas that extend across all interviews, emphasises context (Vaismoradi, Turunen & Bondas, 2013). Based on the literature review, the challenges identified were higher-level and individual-level contextual factors considered as the basis for the themes.

The data analysis was based on key thematic areas identified in the theoretical framework, MultiTAU. As per Sangasubana (2011), the existing literature that was reviewed provided patterns and related theories to interpret the data collected.

Based on Venkatesh *et al.*'s (2016) MultiTAU model, the following areas were explored:

- higher-level contextual factors:
    - environment attributes
    - location attributes;
- the baseline model:
    - individual beliefs
    - facilitating conditions
- individual-level contextual factors:
    - user attributes and
    - technology attributes.

The steps for thematic analysis included the preparation, organisation and reporting of the transcribed interviews (Cresswell, 2014). Data were analysed using Atlas.ti software, following these steps.

Based on Sangasubana (2011):

1. Textual data were grouped and categorised according to the baseline model, higher-level and individual-level contextual factors, to reduce large amounts of data into more manageable pieces of work;
2. Themes were created within groups, as per sub-bullets (e.g. environmental attributes and location attributes); and
3. Cases not fitting with the other groups or categories were identified to receive an additional analysis.

Data were coded according to Table 25.

Table 25 Atlas.ti code manager

CODE	GROUNDED (FREQUENCY)	CODE GROUPS
Access to the internet	10	Environmental attributes
Ask family members for help	12	Social influence
Cellphone	7	Facilitating conditions
Cost	15	Environmental attributes
Data costs	18	Environmental attributes
Face to face (f2f) contact	16	Social influence
Lack of awareness	39	User attributes
Lack of skills	17	User attributes
No internet access	8	Environmental
Not useful	15	Performance expectancy
Smart Phone	10	Facilitating conditions
Cheaper	48	Suggestions, environmental
Tech usage	35	Use
Unnecessary	26	Performance expectancy
Willingness to use ICT	2	Behavioural intention
Culture	5	Location attributes
Training	10	Facilitating conditions
Complex	13	Effort expectancy
Diet	4	Self-management
Exercise	3	Self-management
Other mechanisms	7	Mechanisms
Easier to use	20	Effort expectancy
Incorporate into my life	12	Effort expectancy
Interoperability	6	Technology attributes
Privacy	9	Technology attributes
Security	7	Technology attributes
Age	15	User attributes
Self-efficacy	12	User attributes
Habit	0	Habit

5.3 Findings

To reach the objectives and themes were coded according to the constructs identified from the MultiTAU model, included above. Higher-level contextual factors include environmental and location attributes. Individual-level contextual factors include user attributes and technology attributes. The findings are presented below.

5.3.1 Higher-level contextual factors

As stated in section 2.4.9, higher-level contextual factors in this research, as per the MultiTAU model, focus on the environment ("the physical environment and conditions in which the target technology is used") (Venkatesh *et al.*, 2016:344) and location attributes (the "location where the target technology is implemented or introduced") (Venkatesh *et al.*, 2016:344).

5.3.1.1 Environment attributes

Access and affordability were identified in section 2.5.1. The findings support this view as economic barriers identified in this study are directly related to the cost of obtaining devices capable of supporting m-health applications or features. Additionally, the cost of establishing an internet connection to manage their conditions was also a challenge.

Data costs were identified as a common factor hindering participants' use of ICT. For many, the prevailing high cost of data limits the use of these technologies to a few days per month. The data cost barrier was identified across all age groups, as responses across all age groups included, *"I don't always have money to buy data"* and *"No sir; I do not have money for data as data is too expensive"*. Even though participants have access to the necessary devices to support m-health applications, due to limited financial resources, they cannot afford to purchase the data necessary for using these applications daily. This was summarised by the following response from a male between 25 and 34 years old: *"Look, lots of apps use lots of data, so I think they should create technology like an app that doesn't have any cost involved, just a normal app that you can install perhaps on your phone"*.

Respondents indicated that apps should not require data to use. This is a salient factor as many people prefer spending their funds on supporting their families with basic needs rather than spending it on m-health apps. This was summarised by respondents who stated:

"They [m-health apps] *are quite costly & being a family man, it can be hard to afford"* and

"I feel if those types of technology are made more available, at a more affordable price, then that would really help people".

Additionally, the generally dire economic circumstances of participants imply that they cannot afford devices such as glucose meters or mobile phones in their totality. Participants indicated that they could not afford the glucose meter and its necessary accessories; for example, the testing strips which are inserted into the machine. Participants lamented that these testing strips which form part of the self-management process, while quite costly, are not freely provided.

5.3.1.2 Location attributes

Location attributes refer to cultures in the Western Cape. Evidence indicates that culture impacted diabetes self-management due to diet. This was highlighted by the following quote: *"My culture does affect my lifestyle because I do not come from a wealthy family background, I cannot afford to be cooking two meals, and the other thing is, I am not allowed to eat red meat, but due to the rituals that take place at home. I am forced to eat red meat".*

Social norms play a role in culture as the influence of family has a potentially negative impact on diet. The following quotes highlighted this: *"I eat what my family eats, even if it's unhealthy".*

"As a Cape Malay Muslim, food is basically the centre of all our social gatherings"; and

"Our culture includes traditions such as koeksisters on a Sunday. My wife specifically makes koeksisters on a Sunday, and it's become a norm to eat every Sunday. Also, we have family gatherings on Fridays after Mosque whereby everyone gets together to and has lunch and dessert".

However, this was contradicted by other respondents who indicated that culture is used as an excuse and that following a healthy diet is the responsibility of the individual.

The impact of culture on exercise was not explicit. However, evidence indicated that there is a preference for watching TV as opposed to exercising.

Evidence indicates that older respondents were more traditional and preferred visiting the doctor or clinic to using m-health apps, a view summarised by the following quote: *"I am* *more traditional and rely on doctors and nurses to do my reading of blood and sugar levels [at the local clinic]"*.

The use of alternative medicine was also evidenced by the following quote: "*in my culture, we usually use traditional medicine to cure illnesses*". However, unless the traditional medicine is accompanied by self-management activities, for those with type 2 diabetes, it may result in diabetes complications, particularly if the traditional treatment is not medically effective in controlling blood glucose levels.

Religion was also indicated as a factor preventing m-health app usage, evidenced by the following quote: *"As a Christian, I put my trust in the Lord and not a mobile app to improve my health"*.

Respondents specified that culture did not affect their use of diabetes m-health applications but a lack of funding (environmental attributes) and e-skills (user attributes) did. These factors were highlighted by the following quotes:

"My culture has nothing to do with me not using the mobile application. I cannot afford a phone that uses applications due to affordability" and *"I am not used to this whole technology thing so it's hard [difficult] for to use mobile application"*.

5.3.2 Baseline model

As stated in section 2.4.9, the baseline model in this research refers to UTAUT and UTAUT2 variables such as performance expectancy and effort expectancy.

5.3.3 Individual beliefs

According to Venkatesh *et al.* (2016), individual beliefs such as performance expectancy, effort expectancy and social influence are those influencing behavioural intention. This was supported by the findings in the domain of real (section 4.7) which highlighted that the relationships between performance expectancy, effort expectancy, social influence, facilitating conditions and behavioural intention were all significant.

5.3.3.1 Performance expectancy

Respondents indicated that they did not believe that using ICT, such as m-health apps, would assist them to attain better health. This was highlighted by the following quotation: *"I don't see the purpose. I receive everything from my testing machine when I see it"* and *'I don't want to play with my health and get things wrong and end up making myself sick. I'm comfortable with the doctors handling the heavy work"*.

Evidence indicates that respondents believed that there is no need for m-health apps because their condition is manageable: *"I don't use anything else because I don't see the need to. I have my family to help me, and if I need more info I will ask one of them to find out for me, or I will get the information when I go to the doctor again"*

Older respondents use their mobile phones to make phone calls and thus, their willingness to use m-health is lower.

5.3.3.2 Effort expectancy

Evidence indicated that respondents dislike using technology as it is too complicated for older people as well as too difficult for them to use. One respondent admitted, *"For the older generation, technology can be a bit complex to use"*.

Furthermore, respondents insisted that using m-health apps will be easier than using the traditional approach to seek medical consultation. Attending health care facilities is inconvenient for elderly patients as they often must wait for hours or even a full day to be examined by a professional. Therefore, using m-health will allow more time for other activities.

A respondent revealed, *"I really do not know, I take it from myself, it's difficult for me because my eyes are blurry"*. The interface should be user-friendly for older patients to incorporate into their daily lifestyles. Moreover, respondents use other tools such as glucose meters rather than m-health apps, as these meters are easy to use and understand. Furthermore, individuals mentioned that while operating m-health apps was not easy at first, after numerous attempts it became easier. This was summarised by the following comments, *"Found it challenging in the beginning"* and *"I struggled at first, but I think I'm getting better now"*.

5.3.3.3 Social influence

Respondents indicated their belief that family and friends encouraged m-health apps usage to manage their diabetes. However, the results also indicated that respondents preferred the assistance and social support of family and friends as opposed to using a device for self-management activities.

Respondents also indicated that having in person (face-to-face) consultations with healthcare professionals provides a more accurate representation of their condition than using m-health, as summarised by the following statements: *"I still feel that it is imperative to get the opinion of a trained and qualified professional and not depend on applications"* and *"[I]feel like the doctor is more accurate at giving results"*. This suggests a weak trust in using m-health.

5.3.3.4 Facilitating conditions

Venkatesh *et al.* (2016) state that facilitating conditions will have a direct impact on usage. Respondents indicated that despite having access to a cell phone, respondents do not have the necessary resources to download m-health apps as it requires certain software and data / WIFI to download, update and track the results on an application.

The study findings indicated that individuals believed that technology and m-health could improve their condition but that they required assistance from their local healthcare clinic. *"Clinics and governments need to teach us how to use technology"*. Moreover, evidence indicated that respondents are open to the use of m-health when there is a help facility available for queries.

Lack of training was identified as a reason for the lack of or discontinuation of use, further illustrating that respondents may accept and use m-health provided that a specific person is available for assistance with m-health difficulties. Respondents indicated that they are unable to afford training. Respondents further stated that when training is provided, they are not aware of it. Respondents mentioned that they *"Don't have the right training for it"*, *"People can't afford to learn" and "do not know when it [training] is available"*.

5.3.3.5 Habit

Qualitative evidence did not suggest that habit was an important factor as it was not coded in any of the interview transcripts. However, literature states the contrary (Venkatesh, Thong &

Xu, 2016). Therefore, it was necessary to test this variable via qualitative methods to confirm or disprove the literature.

5.3.3.6 Behavioural intention and use

Two respondents indicated that they intend to use ICT, such as m-health applications, to manage their diabetes in the next month. Additionally, a willingness to learn use ICT was suggested by the following statement: *"No, I never used the internet yet, but I would like to learn"*.

Evidence indicated that respondents used glucose testing machines: *"No, I don't use any other technology besides the Accu-chek machine"*. However, other respondents indicated that they did not own one.

One comment indicated a preference for alternative mechanisms such as continuous glucose monitoring: *"I wish there was a system to tell me when my sugar is low or high without me pricking myself every time. I strongly feel technology will help us diabetics"*.

5.3.4 Individual-level contextual factors

Venkatesh *et al.* (2016) include user attributes and technology attributes as individual-level contextual factors. As stated previously, *user attributes* refer to "individuals who use technologies to assist them in performing their tasks" (Venkatesh *et al.*, 2016:344). *Technology attributes* refer to the "IT artefact that individual users use in carrying out their tasks" (Venkatesh *et al.*, 2016:344). In the case of this research, this refers to the use of m-health applications for diabetes self-management.

5.3.4.1 User attributes

Respondents admitted that using m-health apps was intimidating, primarily due to respondents having limited ICT experience and minimal skills related to m-health apps. As this was increasingly prevalent as the age of respondents went up, the usage became correspondingly lower. This is linked to (computer) **technology anxiety**.

Amongst older participants, though, a lack of e-skills was identified as the main reason for not using m-health apps: *"I think it's too complicated and makes it too difficult for me to* *understand and it takes a lot of time for me to use so because of the time I sometimes don't feel like using it."* Therefore, this would have a negative impact on using m-health apps.

Evidence indicated that respondents are unable to complete self-management activities using m-health. Therefore, the design of an m-health application is regarded as a challenge as patients cannot use the m-health apps on their own. This is linked to **self-efficacy,** defined as *"people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives"* (Bandura, 1994:2).

Food security was highlighted during an interview with a respondent over 50 years:

Fazlyn: Would m-health applications help you to manage your diabetes better?
Respondent: No
Fazlyn: Why not?
Respondent: It's not something that I want to use; it's not easy and it's too expensive to buy data.
Fazlyn: *(Note: realising that m-health apps may not be the solution, then trying to establish if another mechanism would be more appropriate for this user group)* If an m-health app won't help you, would you prefer having a free glucose testing machine and free testing strips, if this were possible?
Respondent: This won't help me to manage my diabetes better either.
Fazlyn: *(Note: Really surprised as managing blood glucose levels is a really important self-management activity and allows patients to make the necessary changes to their diabetes treatment and prevent diabetes complications)* I don't understand. Why would having a glucose meter and strips *not* help you to manage your diabetes better?
Respondent: I know that a glucose testing machine will show me what my blood glucose level is but I also know that the food I eat is responsible for the number [on the glucose testing machine]. *(Note: respondent understands the impact of diet on diabetes self-management).* What you're not understanding is that if I can only afford to buy bread and jam with my pension (state grant for the elderly equal to approximately R1500 ($120) per month) then it doesn't matter whether I have a glucose machine or not or if they provide the testing strips free or not, because it won't make a difference to my diabetes if I only have enough money to buy certain foods or go hungry. *(Note: understands that high carbohydrate food raises blood glucose levels).*

The above conversation evidenced a level of health literacy as the respondent understood the impact of diet and blood glucose monitoring on diabetes self-management. However, economic factors impacted food security and the ability to purchase healthy food, thereby negatively affecting diabetes self-management and increasing the risk of developing diabetes complications.

5.3.4.2 Technology attributes

When asked the reason that m-health apps are not for self-management, it was noted that not all respondents have access to a Smartphone. This is highlighted by the following quotations: *"No, because I don't have a smartphone"* and *"No, I don't use technology"*. This is also identified as the reason for not connecting to the internet, as a respondent stated, *"No, my phone is too old"*.

Respondents identified access to internet facilities as a barrier. Internet connection in the residential areas are available; however, an individual's internet connection is dependent on the cost of data. The younger participants highlighted the use of mobile devices and various methods of internet connection such as Wi-Fi and prepaid data. This was summarised by the following quotes, from two female participants, aged between 35 and 49: "*Wi-Fi yes, I'm using my daughter's*" and "*We have Wi-Fi at home, so it's convenient for me to make use of the internet*".

Other respondents stated that while they have access to the internet, it is mainly used for social media such as WhatsApp, Facebook and phone calls as opposed to diabetes self-management.

Interoperability was identified as a challenge to the acceptance of m-health apps. Evidence indicated that m-health apps are not compatible with other systems, such as glucose testing machines. Therefore, for patients to monitor their self-management activities, they must use more than one ICT tool.

Respondents indicated that privacy and security are concerns as they fear that others might potentially obtain their personal information, as evidenced by the following quote: "*I do not want my personal information to be accessible to the public*".

A recommendation offered by several respondents for improving usage was that ICT, such as m-health apps, should be *"cheaper, easier to incorporate into my daily life and easy to understand"*.

5.3.5 Data triangulation

The reliability of results was ensured through the use of data and investigator triangulation (Denzin, 1978). Quantitative and qualitative data were collected by field workers. This allowed for the data comparison to determine if there is "convergence, differences or a combination" (Cresswell, 2014:213). This allowed findings to be confirmed, disconfirmed, cross-validated or corroborated (Greene, Caracelli & Graham, 1989). The findings are displayed in Table 26 below:

Table 26 Triangulation of quantitative and qualitative findings

Variables	Quantitative findings	Qualitative findings	Discussion
Performance Expectancy	Performance expectancy had the lowest strength of association with behavioural intention to use ICT for diabetes self-management.	Respondents indicated that they did not believe that using ICT would assist them in achieving better health.	Quantitative findings were, therefore, converged with qualitative findings. There were several additional factors mentioned in the qualitative data such as privacy, security and interoperability.
Effort Expectancy	Effort expectancy had the highest strength of association with behavioural intention to use ICT for diabetes self-management.	Respondents mentioned their dislike for using ICT due to the complexity, especially for older people. They also said it was too difficult for them to use.	Quantitative findings were confirmed by qualitative findings; in that effort, expectancy was a key factor for behavioural intention. Additional factors established from qualitative data included technology anxiety and self-efficacy. This could explain the low usage found in the quantitative data.
Social Influence	Social influence showed a significant effect on behavioural intention (p value=0.000).	Results indicated that family and friends encouraged m-health usage for the management of their diabetes.	Quantitative findings were corroborated with qualitative results. However, it was found that respondents preferred the assistance and social support of family and friends as opposed to using a device for self-management activities. This could be a key factor underlying the low usage.

Facilitating Conditions	Facilitating conditions had the second highest strength of association with behavioural intention to use ICT for diabetes self-management.	Cost and the lack of smartphones were identified as critical factors.	Qualitative findings supported quantitative findings. Additional factors included a lack of training, required support from clinics and access to a help function or a support person to assist with m-health user difficulties. These factors were identified as a reason for the lack of use or the discontinuation of use.
Behavioural Intention	Results indicated that the four variables had a moderate explanatory power of 50.6% for behaviour intention.	There were few comments related to behavioural intention. Two respondents indicated that they intend to use ICT to manage their diabetes in the next month. There was also a willingness to learn how to use ICT.	Qualitative findings provided little support for quantitative results. However, there were no significant differences mentioned.
Use	Results indicated a low level of diabetes self-management activities. Despite the availability of free m-health options and a high behavioural intention, almost 70% of patients did not use forms of ICT, such as m-health. Instead, they preferred to use glucose testing machines.	Respondents indicated their preference to use glucose testing machines as well as their use of ICT for social media, such as WhatsApp and Facebook, instead of m-health activities.	Qualitative findings provided insight into the underlying reasons for the low usage of ICT for diabetes self-management. This included items such as cost, security, technological anxiety and self-efficacy.

5.4 Chapter summary

The chapter commenced with the analysis of the qualitative data obtained from interviews, completed to understand the underlying reasons for the low usage, as determined in the previous chapter. Findings identified MultiTAU variables – such as those included in the baseline model (EE, PE, SN, and FC) as well as higher-level (environmental and location attributes) and individual-level contextual attributes (user attributes and technology attributes) – were identified as potential challenges. Additionally, technology anxiety and a lack of self-efficacy were identified as possible reasons for low usage. These variables were incorporated into the conceptual framework in the upcoming chapter.

This chapter, concluding with the triangulation from the domain of real and the domain of actual to ensure results reliability, found that all quantitative results were supported by qualitative results. No differences in findings were noted. The next chapter discusses the development of a conceptual framework, constructed from key findings from both domains and the literature.

CHAPTER 6 – Domain of empirical

When I started working, medical aid was part of my benefits. I was able to obtain my insulin and glucose testing strips from the pharmacy without having to wait at the hospital or clinic for hours every month. As I worked hard and my financial status improved, I spent more money on managing my diabetes. Despite a comprehensive medical aid plan, my current insulin pump, that replaced my need for injections, required a R25000 (US$1700) co-payment. This was the price of a small second-hand car. My money or my life? My medical aid also partnered with CDE, so I was able to link their CDE app to my CDE endocrinologist. It had all the elements of a great app, but it did not allow me to register. I tried several times and sent them an email. I noticed online that there were other comments regarding the problems with the registration process as well. They responded to my email stating that they had fixed the problem but I never went back to register; so never used it. The CDE app isn't available any longer. No great loss; because if it can't even let me register, how can I trust it with the most valuable thing to me, my health?

6 Domain of empirical

This chapter aims to answer the research sub-question: ***How can the factors that influence the acceptance and use of m-health applications for diabetes self-management be synthesised into a framework of technology acceptance and use?*** The gaps in the literature were laid out in section 2.6. Some gaps, such as the need to identify contextual factors impacting the use of m-health apps, were investigated in the domains of real and actual. The domain of real analysed mechanisms (access to ICT), structures (current level of ICT access) and events (use of ICT for diabetes self-management). The challenges for m-health usage were analysed in the domain of actual, such that it informs the construction of the conceptual framework presented in this chapter.

6.1 Designing the conceptual framework

It is important to note that the conceptual framework was created based on the critical realism definition: "to make sense of causal explanations of individual events in this context, where an event is defined as the behaviour of a given entity at a given time, is to allow that in reality every event taken as an individual instance inescapably includes the behaviour of the composing lower level entities as well" (Elder-Vass, 2013:6).

The critical realist view of causation between the acceptance and use of m-health apps for diabetes self-management in the Western Cape context and the achievement of developmental goals is summarised in Figure 33.

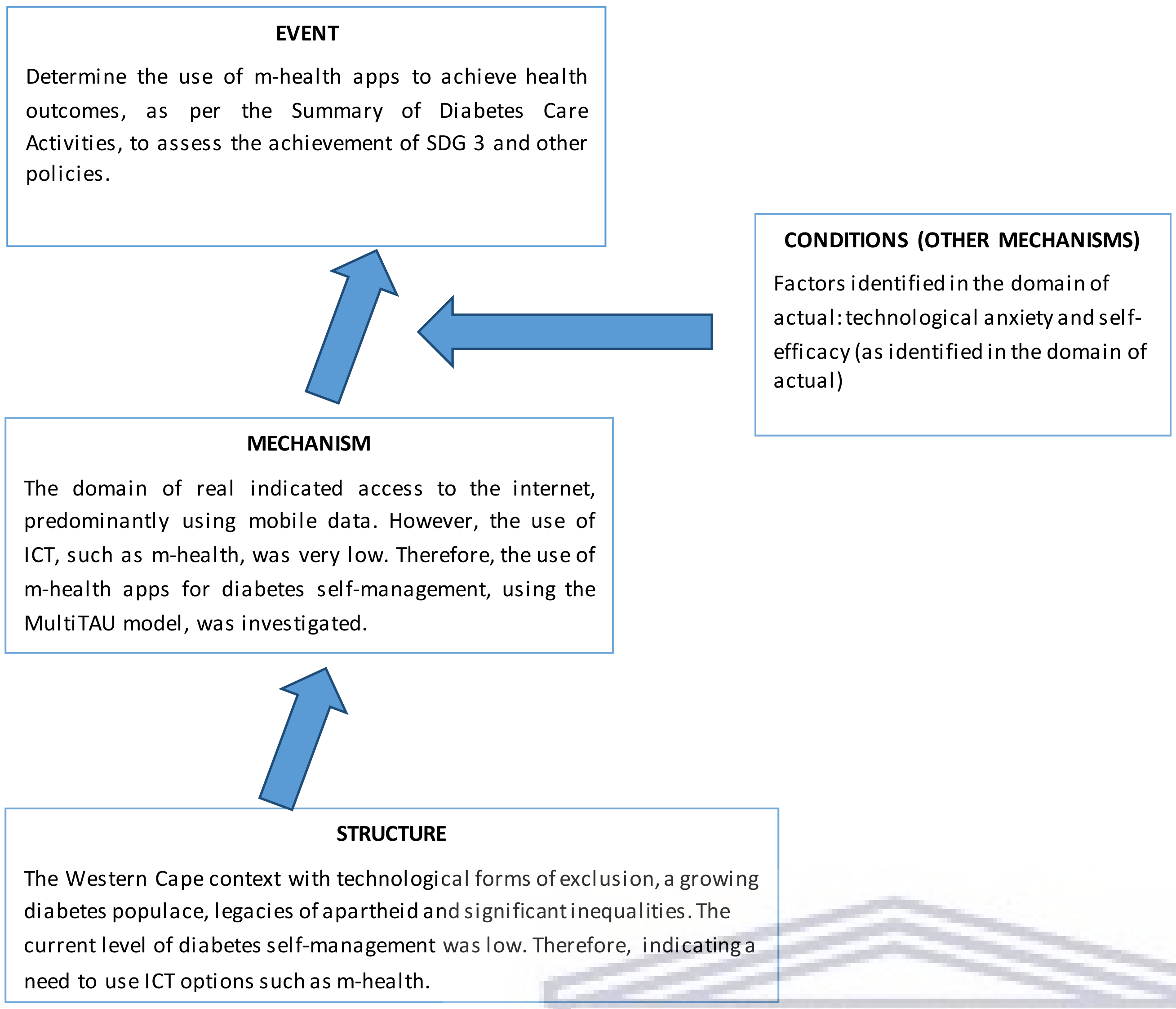


Figure 33 Critical realist view of causation
Adapted from Sayer (2000:15)

Therefore, the emergent conceptual framework consists of the baseline MultiTAU model with an adaptation of introducing higher-level and individual-level contextual factors prevalent in the Western Cape.

6.2 Data collection

This section covers the sampling method, the instrument used, instrument administration and data screening.

6.2.1 Sampling

The work for the domain of empirical employed purposive sampling (Marshall, 1996). Quantitative data was collected from diabetic patients living predominantly on the Cape Flats, in the Western Cape, and then systematically analysed and modelled.

The sampling for the domain of empirical used the same method as the domain of real. As stated, the mid-year 2018 population estimates for South Africa by province indicate that the Western Cape population is 6 621 100 (Statistics South Africa, 2018c). With the national diabetes prevalence estimated at 8.39% (Statistics South Africa, 2016), this would equate to a target population of 555 510 people with diabetes. The minimum sample size for this population was 384. The minimum sample size was calculated at a 95% confidence interval, using Raosoft online calculator (Raosoft, 2019).

A total of 541 responses were collected by field workers using online surveys. Field workers would ask the survey questions, clarify and explain any questions that were not understood, then capture responses in the online survey. An 8-point Likert scale was used: from Not At All True (0) to Very True (7).

Data cleansing involved removing responses that had more than 10% missing values and had values that were the same (standard deviation=1) (Gaskin, 2016). Thereafter, 514 responses were utilised in the analysis. This sample size could result in a 4.32% margin of error (Raosoft, 2019).

6.2.2 Instrument

An online survey was used, utilising Google forms (refer to section 10.3.2). The survey included several sections:

1. access to ICT;
2. summary of diabetes self-care activities;
3. diabetes complications;
4. user acceptance of mobile health for diabetes self-management; and
5. biographical information.

The section describes the administration of the instrument, as well as data cleansing, e.g. data screening and missing data management, concluding with the measurement of construct reliability and validity, and finally, discriminant validity.

6.2.3 Instrument administration

Third-year Information Systems students were trained and deployed as field workers. This method of administration was selected as the pilot study indicated that older patients did not understand key terms in the survey. For example, some respondents did not know that they were using the internet, although they used social media such as WhatsApp. Therefore, field workers completed an online survey on behalf of patients with diabetes, as it was necessary to explain ICT-related concepts to obtain more reliable information.

Field workers were from the B.Com third-year class at the University of the Western Cape, who majored in Information Systems. These students were preferred given that they would have a satisfactory level of digital skill.

The research provided training to familiarise the field workers on the use of the instrument. Further checks were done to ensure that they were adequately prepared. The fieldworkers' role were to collect data due to the extensive data collection a team was necessary.

The risk of bias by using students as field workers was reduced through the use of structured instruments. Field workers were conversant in the language of their respondents. The use of quantitative structured instruments reduces the risk of bias. The online survey used Google forms. An even Likert scale of eight items, from 0 (strongly disagree) to 7 (strongly agree) was used. A total of 541 responses were collected via the field workers.

6.2.4 Data screening and missing data management

Data screening and missing data management are required as this may affect the results obtained, especially when using PLS-SEM (Hair *et al*., 2017). Based on Gaskin (2016), responses that had more than 10% missing values or which had values that were all the same (standard deviation=1) were removed. The remaining 514 responses were utilised. Construct reliability and validity was assessed to ensure data could be used to test the hypotheses.

6.3 Construct reliability and validity

As defined earlier, *reliability* is the ability of an instrument to measure the underlying variables accurately. The construct reliability and validity of the data were assessed first. The values for Cronbach's alpha were used to evaluate the internal consistency of the survey questions (Gliem & Gliem, 2003). A value of 0.6 is an accepted benchmark (Kline, 2013).

Therefore, the internal consistency of all the variables meets the level of acceptance as they were higher than 0.7.

Composite reliability, a test of convergent validity, may be preferred to Cronbach's alpha as it may provide closer estimates for truer reliability (Garson, 2016). As with Cronbach's alpha, the range for composite reliability is between 0 and 1 (Lowry & Gaskin, 2014). The closer the value is to 1, the better the estimated reliability (Garson, 2016). A composite reliability value equal to or greater than 0.7 indicates the model's adequacy for confirmatory purposes (Lowry & Gaskin, 2014). Given that the values for composite reliability are all greater than 0.8 in Table 27, the model is suitable for confirmatory research, according to Garson (2016).

The average variance extracted (AVE) was used to test convergent and divergent validity. AVE reflects "the average communality for each latent factor in a reflective model" (Garson, 2016:56). AVE measures "the level of variance captured by a construct versus the level due to measurement error" (Alarcón & Sánchez, 2015:5/1). AVE values should exceed 0.5, which then that factors "explain at least half the variance of their respective indicators" (Garson, 2016:56). However, Fornell and Larcker (1981) stated that if an AVE is less than 0.5, it can be accepted *if* the composite reliability is greater than 0.6. This is the case with the 'use' variable where the composite reliability is 0.827; therefore, the AVE of 0.450 is acceptable.

Table 27 M-health usage construct reliability and validity results

	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Behavioural Intention	0,972	0,982	0,947
Effort Expectancy	0,937	0,955	0,842
Facilitating Conditions	0,803	0,864	0,560
Habit	0,875	0,914	0,728
Performance Expectancy	0,930	0,950	0,826
Self-efficacy	0,907	0,935	0,782
Social Influence	0,884	0,920	0,743
Technology anxiety	0.616	0.616	0.517
Use	0,754	0,827	0,450

6.4 Discriminant validity

Discriminant validity is required to prevent multicollinearity issues (Ab Hamid *et al.*, 2017). *Multicollinearity* refers to the existence of high intercorrelations amongst independent variables. The PLS correlation coefficient matrix was used in this study to assess discriminant validity. According to Gaski and Nevin (1985), there are two criteria to test discriminant validity: that the correlation coefficient between the two variables must be less than 1; and that the correlation coefficient of the two variables must be less than the individual Cronbach's alpha. As per

Table 28, the correlation coefficient of the two variables was less than 1. Moreover, the correlation coefficient of the two variables was less than the individual Cronbach's alpha. Discriminant validity, according to Fornell and Larcker (1981), can be determined by comparing the square root of the average variance extracted. In

Table 28, the square root of the average variance is represented by diagonal values. As per Lowry and Gaskin (2014:27), the diagonal elements must be greater than the off-diagonal elements for the same row and column, not the AVE value itself. The diagonal values in

Table 28, higher than any other correlation, means that all criteria for discriminant validity have been satisfied.

Table 28 Correlation coefficient matrix

	Behavioural Intention	Facilitating Conditions	Habit	Performance Expectancy	Self-efficacy	Social Influence	Technology Anxiety	Use
Behavioural Intention	**0,973**							
Facilitating Conditions	0,610	**0,764**						
Habit	0,566	0,554	**0,853**					
Performance Expectancy	0,636	0,709	0,556	**0,909**				
Self-efficacy	0,619	0,755	0,514	0,688	**0,885**			
Social Influence	0,600	0,606	0,417	0,638	0,567	**0,862**		
Technology Anxiety	-0,185	-0,269	-0,129	-0,115	-0,231	-0,089	**0,719**	
Use	0,402	0,401	0,292	0,461	0,359	0,486	-0,068	**0,711**

Given that the data meets the criteria for construct reliability, validity and discriminant validity, it was used to test the hypotheses.

6.5 Data analysis

PLS-SEM that was used in the domain of real to analyse the acceptance and use of ICT for diabetes self-management was also used to test the conceptual framework. PLS-SEM is a non-parametric method, meaning that data does not need to be normally distributed.

Therefore, the Shapiro-Wilk test to determine normality was not run in SPSS software (Ghasemi & Zahediasl, 2012). Other advantages are indicated in section 4.6.1.1.

To recap, the PLS-SEM path coefficients test assessed the strength and direction of the relationship between the variables, as defined in the hypotheses (Huang *et al.*, 2013). A positive influence is indicated by a positive path coefficient. Alternatively, a negative path coefficient presents a negative influence.

R^2 provides a model fit measure (Garson, 2016). R^2 predicts which value of the dependent variables can be explained by the independent variables. The variance in the percentage is representative of the predictive power of the research model, its values ranging from 0 and 1.

The significance of the results, such as Cronbach's alpha, path coefficients and R^2, are generated by a bootstrap procedure. According to Hair *et al.* (2017:304), *bootstrapping* "is a resampling technique that draws a large number of subsamples from the original data (with replacement) and estimates models for each subsample. It is used to determine standard errors of coefficients to assess their statistical significance without relying on distributional assumptions". The number of subsamples must be large to ensure the stability of results. Therefore, based on Hair *et al.* (2017), a bootstrap subsample of 5000 was used for the preparation of the final results.

In this study, the p-value, generated by bootstrapping, was used to test the hypotheses (Hair *et al.*, 2017). R^2 was used to determine the predictive power of the model.

6.6 Baseline model hypotheses

Four independent variables – PE, EE, SI and FC – tested in the preliminary research model were found to have a positive effect on behavioural intention to use m-health applications for diabetes self-management. These variables, forming part of individual beliefs in the MultiTAU model, were used as the baseline model for this study.

6.6.1 Performance expectancy

The definition of performance expectancy (PE), for this domain, is the degree to which individuals believe that using m-health apps will improve their diabetes self-management. PE was measured by the perception of whether or not m-health applications are useful tools for managing diabetes activities (Venkatesh *et al.*, 2003).

Activities included tasks such as insulin administration, carb counting and glucose testing, more quickly, as well as improving their chances of obtaining an acceptable HBA1c reading. The blood test for HbA1c level should be routinely performed for people with type 1 and type 2 diabetes. Blood HbA1c levels are reflective of how well diabetes is controlled. As stated previously, Greenwood *et al.* (2017) reported a significant reduction in HbA1c as an outcome measure through the use of technology-enabled diabetes self-management. These activities are related to achieving health outcomes that impact developmental goals. The research hypothesis for this independent variable was as follows:

H1: Performance expectancy will have a positive influence on behavioural intention to use m-health applications for diabetes self-management

6.6.2 Effort expectancy

The definition of effort expectancy (EE) for this domain is the degree of ease associated with the use of m-health apps. EE was measured by the perceptions of whether or not it is easy to use m-health applications for diabetes self-management activities as well as the ease of becoming skilful at using the applications (Venkatesh *et al.*, 2003). Therefore, the research hypothesis for this independent variable was as follows:

H2: Effort expectancy will have a positive influence on behavioural intention to use m-health applications for diabetes self-management.

6.6.3 Social influence

Social influence, for this domain, is defined as is the extent to which individuals believe that others who are important to them, influence their use of m-health applications for diabetes self-management (Venkatesh *et al.*, 2003). SI was measured by the perceptions that important others, such as family, friends, their health care teams and support groups, support their use of diabetes mobile applications. The research hypothesis tested for this independent variable was:

H3: Social influence will have a positive influence on behavioural intention to use m-health applications for diabetes self-management.

6.6.4 Facilitating conditions

Facilitating conditions (FC) refer to the extent to which individuals believe that organisational and technical infrastructure exists to support the use of m-health applications (Venkatesh *et al*., 2003). This variable was measured by the perception of the ability to access required resources, as well as to obtain knowledge and necessary support to use m-health applications for diabetes self-management. The effect of FC on usage was not tested in the preliminary model and was therefore included in the conceptual framework. These relationships are provided by Venkatesh *et al.* (2016). The research hypotheses for this independent variable were as follows:

H4: Facilitating conditions will have a positive influence on behavioural intention to use m-health applications for diabetes self-management.

H5: Facilitating conditions will have a positive influence on the use of m-health applications for diabetes self-management.

6.6.5 Habit

Based on the MultiTAU model, habit and facilitating conditions are both theorised to be determinants of behavioural intention and use. *Habit*, defined as the "extent to which an individual believes the behaviour to be automatic", is equated with automaticity (Venkatesh *et al.*, 2012:161). Although habit was not a variable deemed important in the qualitative findings, it was still tested due to literature and the fact that using m-health for diabetes self-management is required daily. Therefore, daily use may equate to behaviour that becomes automatic.

These variables, not tested previously, were included in the conceptual framework to test the impact of the acceptance and use of m-health applications for diabetes self-management. The inclusion was to test the effect of habit on behavioural intention and the use of m-health. The research hypotheses for this independent variable were as follows:

H6: Habit will have a positive influence on behavioural intention to use m-health applications for diabetes self-management.

H7: Habit will have a positive influence on the use of m-health applications for diabetes self-management.

6.7 Baseline model extensions

The contribution to the body of knowledge includes the adaptation of the MultiTAU model for diabetes self-management as well as the extension of the baseline model, as an extension which incorporates two additional variables, namely self-efficacy and technology anxiety.

6.7.1 Self-efficacy

Self-efficacy was a finding from the qualitative analysis in the domain of actual (refer to section 5.4). The use of self-efficacy as a variable is supported by systematic reviews evaluating technology-enabled diabetes self-management education and support (Greenwood *et al*., 2017). Self-efficacy is shown to influence the acceptance of m-health (Zhang *et al*., 2017) as well as being used to understand factors that affect the adoption of m-health by the elderly (Hoque & Sorwar, 2017).

This domain provided a larger sample to test whether or not this finding is a key variable for m-health acceptance and use. As such, it is included as an independent variable in the conceptual framework as well (Venkatesh *et al.,* 2016) to test the impact of self-efficacy on behavioural intention and the use of m-health in this study. The research hypotheses tested for this independent variable were as follows:

H8: Self-efficacy will have a positive influence on behavioural intention to use m-health applications for diabetes self-management.
H9: Self-efficacy will have a positive influence on the use of m-health applications for diabetes self-management.

6.7.2 Technology anxiety

Technology anxiety is defined as "a negative emotional response, and pertains to the fear or discomfort people experience when they think of using or actually use technology" (Deng *et al.*, 2014:214); it's a variable is derived from social cognitive theory (Zhu *et al*., 2018). Technology anxiety has been identified as a concern for older users and has been included as a UTAUT extension (Hoque & Sorwar, 2017). Deng *et al.* (2014) found that technology anxiety affected perceived usefulness. Researchers also found that technology anxiety "has a negative impact on perceived ease of use" for mobile chronic disease management systems (Zhu *et al.*, 2018:22).

Additionally, this was highlighted as a finding in the domain of actual (section 5.4). Therefore, these hypotheses were tested:

H10: Technology anxiety will have a negative influence on behavioural intention to use m-health applications for diabetes self-management.

H11: Technology anxiety will have a negative influence on the use of m-health applications for diabetes self-management.

6.8 Behavioural intention and use

Behavioural intention and use are defined as dependent variables. Behavioural intention is proven to be a direct determinant of use (Venkatesh, Thong & Xu, 2016). Determining the use of m-health apps for diet, exercise, medication, blood glucose testing, foot care and smoking cessation has been discussed in the previous section (refer to Table 6 Comparison between self-management assessment tools).

H12: Behavioural intention will have a positive influence on the use of m-health applications for diabetes self-management.

6.9 Higher-level contextual factors

As stated in sections 2.4.9 and 5.3.1, higher-level contextual factors in this research, as per the MultiTAU model, focus on environmental and location attributes.

6.9.1 Environment attributes

As stated previously, access and affordability were identified in the literature review. Venkatesh *et al.* (2016) explain that the relationship between environmental attributes and the baseline model may have a moderating effect. Moderation implies an "interaction effect, where introducing a moderating variable (moderator) changes the direction or magnitude of the relationship" between the independent and dependent variables (Aiken & West 1991:1). Therefore, the moderating effect of internet access on use was tested to determine if the magnitude of the use variable was stronger for patients with internet access.

H5a: The relationship between FC and Use m-health apps is stronger for patients with internet access.

H7a: The relationship between Habit and Use m-health apps is stronger for patients with internet access.

H9a: The relationship between SE and Use m-health apps is stronger for patients with internet access.

H11a: The relationship between TA and Use m-health apps is lower for patients with internet access.

H12a: The relationship between BI and Use m-health apps is stronger for patients with internet access.

6.9.2 Location attribute

Literature indicates that cultural beliefs are a key factor for technology acceptance and use (Oshlyansky, Cairns & Thimbleby, 2007; Huang, Choi & Chengalur-Smith, 2010; Dehzad *et al.*, 2014; Hoque, 2016). National culture is also included as a location attribute (Venkatesh, Thong & Xu, 2016). Due to the delineation of this study to the Western Cape, the location attribute will refer to the distinct provincial culture rather than national culture.

When respondents were asked whether or not their culture impacted on their ability to adopt m-health applications for diabetes self-management, the majority (66.8%) strongly disagreed while another 16.9% also responded negatively to the statement (responses 1-3) (refer to Table 29).

This view is supported by qualitative findings in section 5.3.1.2, which indicated that culture affected diabetes self-management activities such as diet, but did not impact the adoption of m-health applications. Therefore, culture, as a location attribute, was not included as a variable in the conceptual framework.

Table 29 Impact of culture

Cul_a1. My culture affects my ability to adopt mobile health applications to help manage my diabetes

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	0 Strongly disagree	342	66.5	66.8	66.8
	1	48	9.3	9.4	76.2
	2	21	4.1	4.1	80.3
	3	18	3.5	3.5	83.8
	4	15	2.9	2.9	86.7
	5	17	3.3	3.3	90.0
	6	17	3.3	3.3	93.4

	7 Strongly agree	34	6.6	6.6	100.0
	Total	512	99.6	100.0	
Missing	System	2	.4		
Total		514	100.0		

As this research is not conducted in an organisational context, this variable was also excluded. Instead, the focus was on environmental and user attributes because the Western Cape context was explicitly examined.

6.10 Individual-level contextual factors

Individual-level contextual factors, as stated in section 2.4.9 **Multi-level Framework of Technology Acceptance and Use**, included factors such as user and technology attributes that may impact use. The attributes used in the conceptual framework are explained in further detail below.

6.10.1 User attributes

User attributes, as stated in section 2.4.9 **Multi-level Framework of Technology Acceptance and Use**, refer to "individuals who use technologies to assist them in performing their tasks" (Venkatesh *et al.*, 2016:344). Venkatesh *et al.* (2016) explain that this attribute can include other demographic variables beyond just age and gender. Therefore, this research included education and income for the reasons provided below.

6.10.1.1 Education

Based on the recent Statistics South Africa (2018) General Household Survey, educational attainment in South Africa is improving. Despite 57.8% of South Africans over the age of 60 not having completed at least a Grade 7 qualification, this figure was much lower, only 4.4%, for those aged 20-39. And in the middle, only 5.5% of adults over the age of 20 were considered illiterate. Given that NIDDM is more prevalent among older individuals who may have lower levels of education, the following hypotheses were tested:

H1b: The relationship between PE and BI is stronger for patients with higher education levels.

H2b: The relationship between EE and BI is stronger for patients with higher education levels.

H3b: The relationship between SI and BI is stronger for patients with higher education levels.

H4b: The relationship between FC and BI is stronger for patients with higher education levels.

H6b: The relationship between Habit and BI is stronger for patients with higher education levels.

H8b: The relationship between SE and BI is stronger for patients with higher education levels.

H10b: The relationship between TA and BI is stronger for patients with higher education levels.

6.10.1.2 Income

Low income is identified as a barrier to achieving diabetes treatment goals (American Diabetes Association, 2015). This prevalence is even higher for medication non-adherence among minorities groups and those with low socioeconomic status (Nelson, Mulvaney *et al.*, 2016). Approximately 63% of households in the Khayelitsha and Mitchell's Plain, areas in the Cape Flats, survive on incomes of less than R4166 per month (approximately $296), of which 16.5% have no income at all (Western Cape Government, 2017a).

Research also indicates the income of the household head rather than gender as a significant determinant of household access to ICTs (Pashapa & Rivett, 2017). As access to ICTs is required, I posit that income may affect the use of m-health for diabetes self-management as follows:

H1c: The relationship between PE and BI is stronger for patients with higher income.
H2c: The relationship between EE and BI is stronger for patients with higher income.
H3c: The relationship between SI and BI is stronger for patients with higher income.
H4c: The relationship between FC and BI is stronger for patients with higher income.
H6c: The relationship between Habit and BI is stronger for patients with higher income.
H8c: The relationship between SE and BI is stronger for patients with higher income.
H10c: The relationship between TA and BI is stronger for patients with higher income.

6.10.2 Technology attributes

As stated in section 2.4.9, technology attributes refer to the "IT artefact that individual users use in carrying out their tasks" (Venkatesh *et al.,* 2016:344). This includes the functions and features of the technology (Venkatesh *et al.,* 2016). As this research focused on the use of m-health applications for diabetes self-management, access to the internet is required, as identified in section 2.5. Internet access is also recognised as an environmental attribute. Therefore, internet access has been included in both higher-level and individual-level contextual factors.

6.11 Toward a novel conceptual framework for diabetes self-management

Based on section 6.1 Designing the conceptual framework, and the factors identified above, the novel conceptual framework was developed (refer to Figure 34). Factors in quantitative research are referred to as *variables.*

The independent variables were based on the findings from the domain of real, that individual beliefs (performance expectancy, effort expectancy and social influence) had a positive influence on behavioural intention, the dependent variable. The multi-level framework of technology acceptance and use included habit, which was not tested in the domain of real and was therefore tested here to determine the key factors influencing the use of m-health apps for diabetes self-management.

Additional variables, identified in the domain of actual, namely technology anxiety and self-efficacy, were also included to test the effect on behavioural intention and use (dependent variables) in a larger sample size.

The developmental outcomes, as stated previously, is based on the achievement of long and healthy lives for patients with diabetes. The achievement of this Human Development Index will depend on patients completing activities; based on the summary of diabetes care activities; such as diet, exercise and taking medication. As stated previously, failing to complete these activities will likely lead to morbidity and mortality with a negative effect on the achievement of SDG 3.

Figure 34 graphically illustrates the relationships between the independent variables and the dependent variables, with a possible moderation effect of individual-level- and higher-level contextual factors on the achievement of developmental outcomes, as explained in the previous sections.

6.12 Novel conceptual framework for diabetes self-management

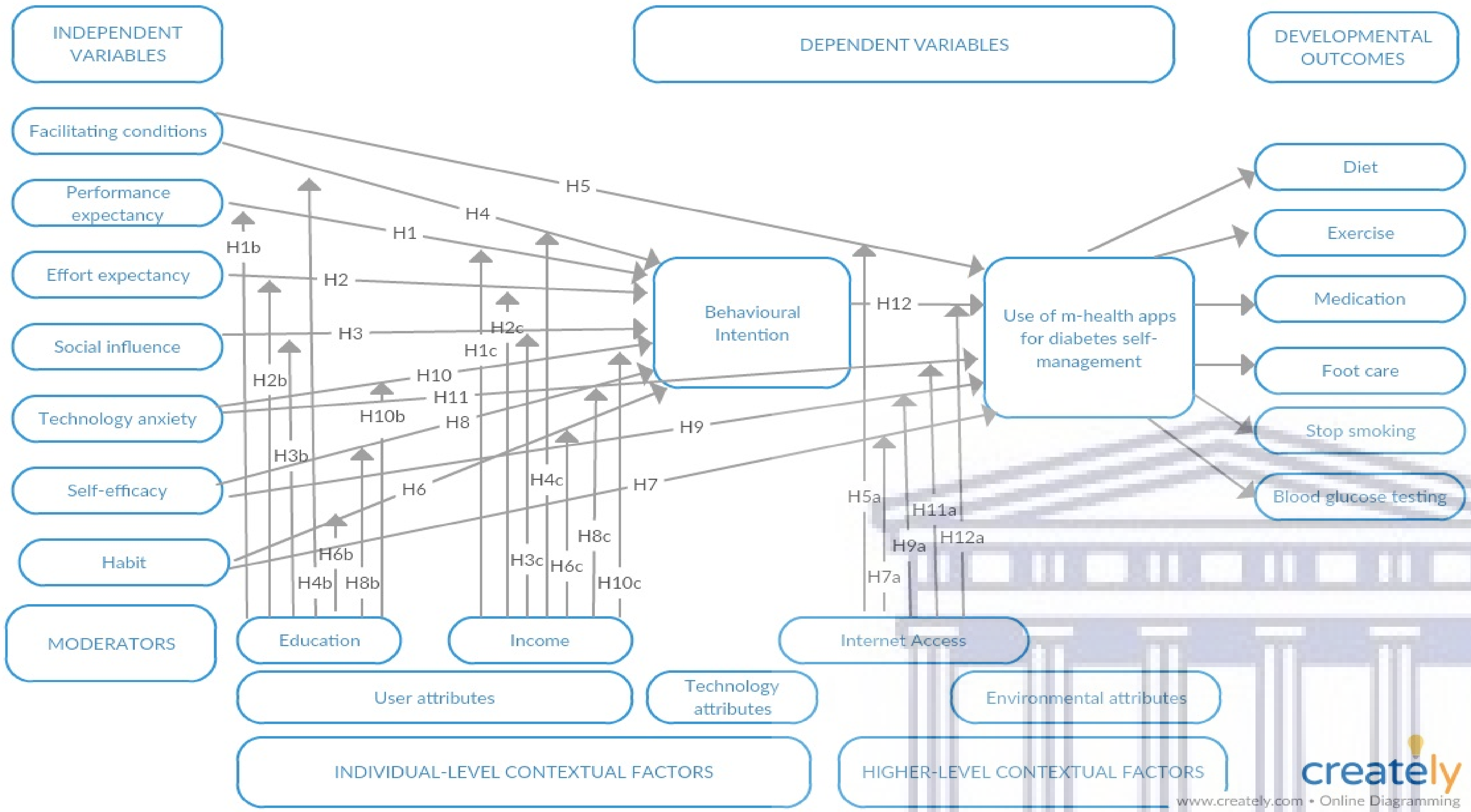


Figure 34 Conceptual framework

6.13 Geographic dispersion of population sample

The sample consisted of patients with diabetes residing in the Western Cape, predominantly in the Cape Town metropole. As stated in section 3.4.3, the 2018 mid-year population estimates for South Africa by province indicate that the Western Cape population is 6 621 100 (Statistics South Africa, 2018a). With the national diabetes prevalence estimated at 8.39% (Statistics South Africa, 2016), this would equate to a target population of 555 510.29 people with diabetes. A sample size of 514 equates to 9.25% of the total diabetic population.

Figure 35 indicates the areas where respondents reside. The top five areas were Belhar (11.9%), Athlone (9.7%), Mitchell's Plain (8.6%), Khayelitsha (4.7%) and Gugulethu (3.5%). This sample was representative of the total diabetic population. However, caution must be applied when attempting to generalise these findings to the entire South African population due to the significant inequalities, even among provinces.

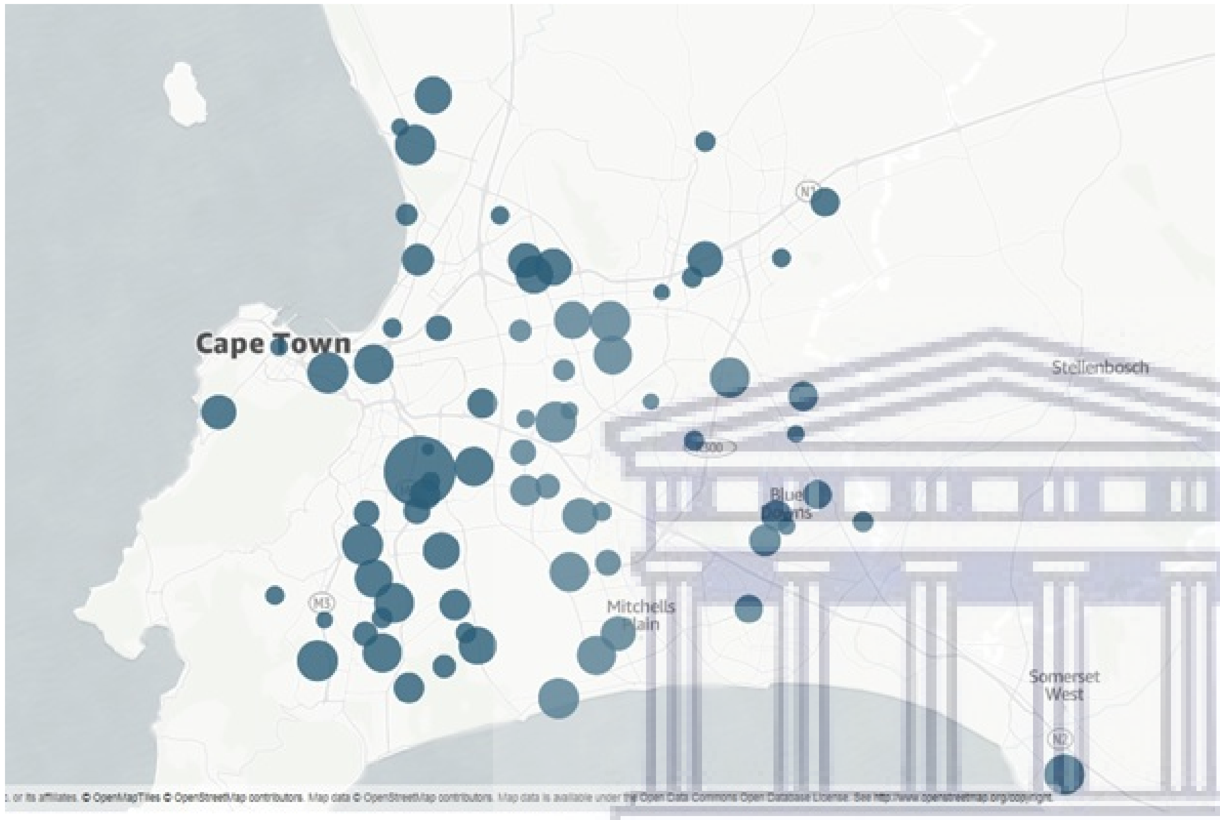


Figure 35 Heat map of respondents' areas

Demographic analysis for the sample was calculated next using descriptive statistics in SPSS software.

6.14 Demographic analysis

Table 30 indicates the demographic information of respondents. The largest proportion of respondents were females (58.6%), older than 50 (39.9%), with type 2 insulin-resistant diabetes, using oral diabetes medication such as Metformin or Glucophage. Despite the highest percentage (23.5%) earning more than R12 000 (approximately $810) per month, the biggest proportion of respondents (46.4%) earn less than R4 000 (approximately $270) per month.

Table 30 Demographic information of respondents

			Frequency	Per cent	Valid Percent	Cumulative Percent
GENDER	Valid		1	.2	.2	.2
		Female	301	58.6	58.6	58.8
		Male	212	41.2	41.2	100.0
		Total	514	100.0	100.0	
AGE	Valid		1	.2	.2	.2
		16 - 24 years	94	18.3	18.3	18.5
		25 - 34 years	85	16.5	16.5	35.0
		35 - 49 years	129	25.1	25.1	60.1
		older than 50 years	205	39.9	39.9	100.0
		Total	**514**	**100.0**	**100.0**	
HIGHEST EDUCATIONAL LEVEL	Valid		4	.8	.8	.8
		Diploma or Certificate	85	16.5	16.5	17.3
		Matric (Grade 12) - Senior Certificate	186	36.2	36.2	53.5
		No schooling	5	1.0	1.0	54.5
		Primary school	20	3.9	3.9	58.4
		Some high schooling	115	22.4	22.4	80.7
		Some primary schooling	13	2.5	2.5	83.3
		Technikon	16	3.1	3.1	86.4
		University degree	70	13.6	13.6	100.0
		Total	**514**	**100.0**	**100.0**	
INCOME	Valid		16	3.1	3.1	3.1
		Less than R500	52	10.1	10.1	13.2
		R12000 or more	121	23.5	23.5	36.8
		R1400 - R2499	82	16.0	16.0	52.7
		R2500 - R3999	44	8.6	8.6	61.3
		R4000 - R6999	72	14.0	14.0	75.3
		R500 - R899	20	3.9	3.9	79.2

	R7000 - R11999	67	13.0	13.0	92.2
	R900 - R1399	40	7.8	7.8	100.0
	Total	**514**	**100.0**	**100.0**	

The educational levels of respondents' data reflect that the majority (69.4%) have been educated through at least Grade 12. Therefore, this could impact the user attribute hypotheses as education may not affect the use of m-health applications. This was tested, as described in the following section, with findings based on testing the conceptual framework, as graphically represented in section 6.12.

6.15 Starting with the baseline model

As explained in section 6.2.1 to section 6.6.5, the following hypotheses were developed and tested:

H1: Performance expectancy will have a positive influence on behavioural intention to use m-health applications for diabetes self-management.

H2: Effort expectancy will have a positive influence on behavioural intention to use m-health applications for diabetes self-management.

H3: Social influence will have a positive influence on behavioural intention to use m-health applications for diabetes self-management.

H4: Facilitating conditions will have a positive influence on behavioural intention to use m-health applications for diabetes self-management.

H5: Facilitating conditions will have a positive influence on the use of m-health applications for diabetes self-management.

H6: Habit will have a positive influence on behavioural intention to use m-health applications for diabetes self-management.

H7: Habit will have a positive influence on the use of m-health applications for diabetes self-management.

H12: Behavioural intention will have a positive influence on the use of m-health applications for diabetes self-management.

These relationships are graphically represented in Figure 36.

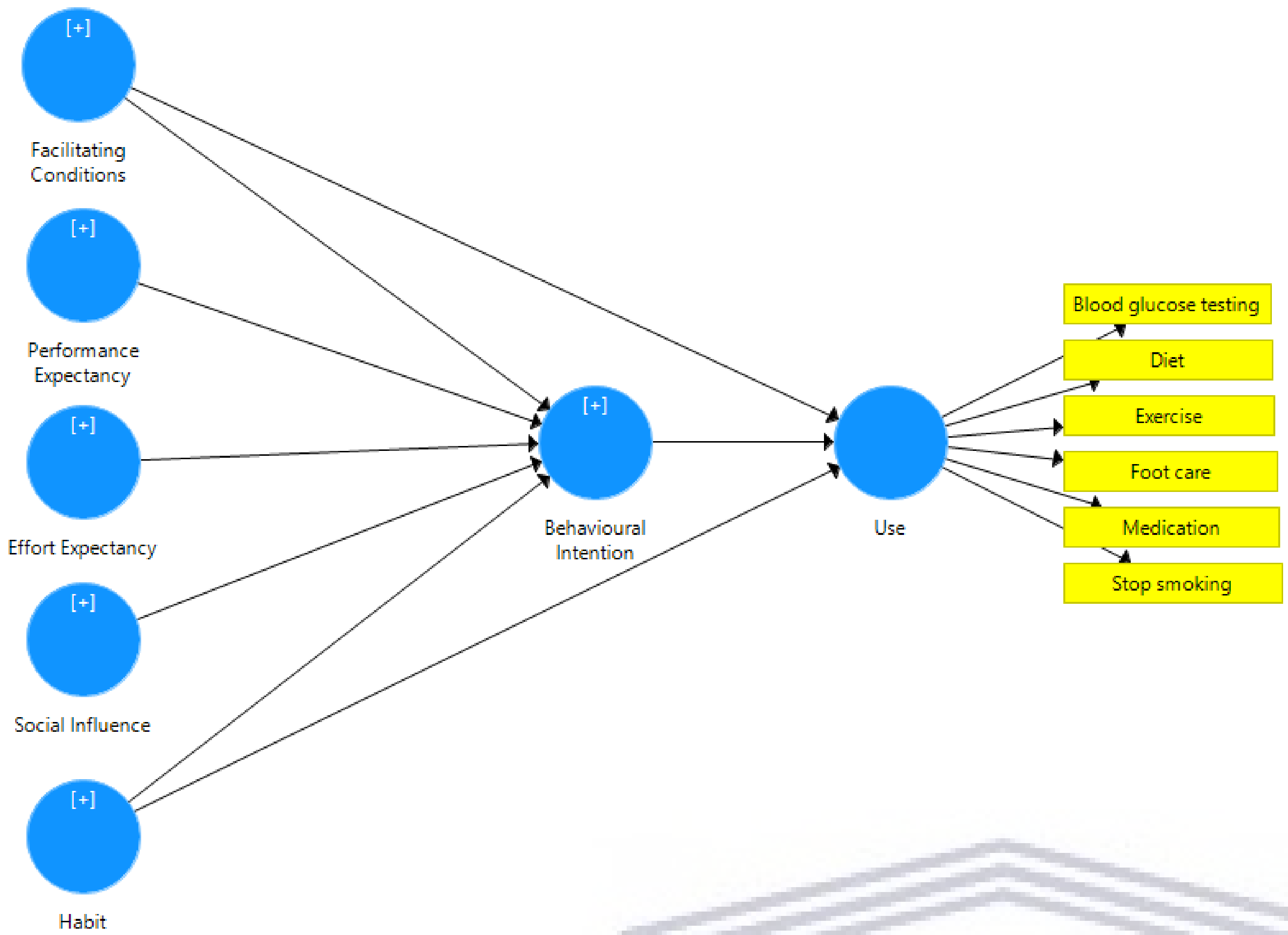


Figure 36 Baseline model

As stated previously, path coefficients were used to test the strength and direction of the relationships between variables. Figure 37 indicates positive relationships between PE, EE, SI, FC and habit with behavioural intention. There is also a positive relationship between FC and behavioural intention and the use of m-health applications for blood glucose testing, diet, exercise, foot care and medication.

SI represents the strongest positive relationship to BI (0.267) while the weakest relationship is habit to use (0.025).

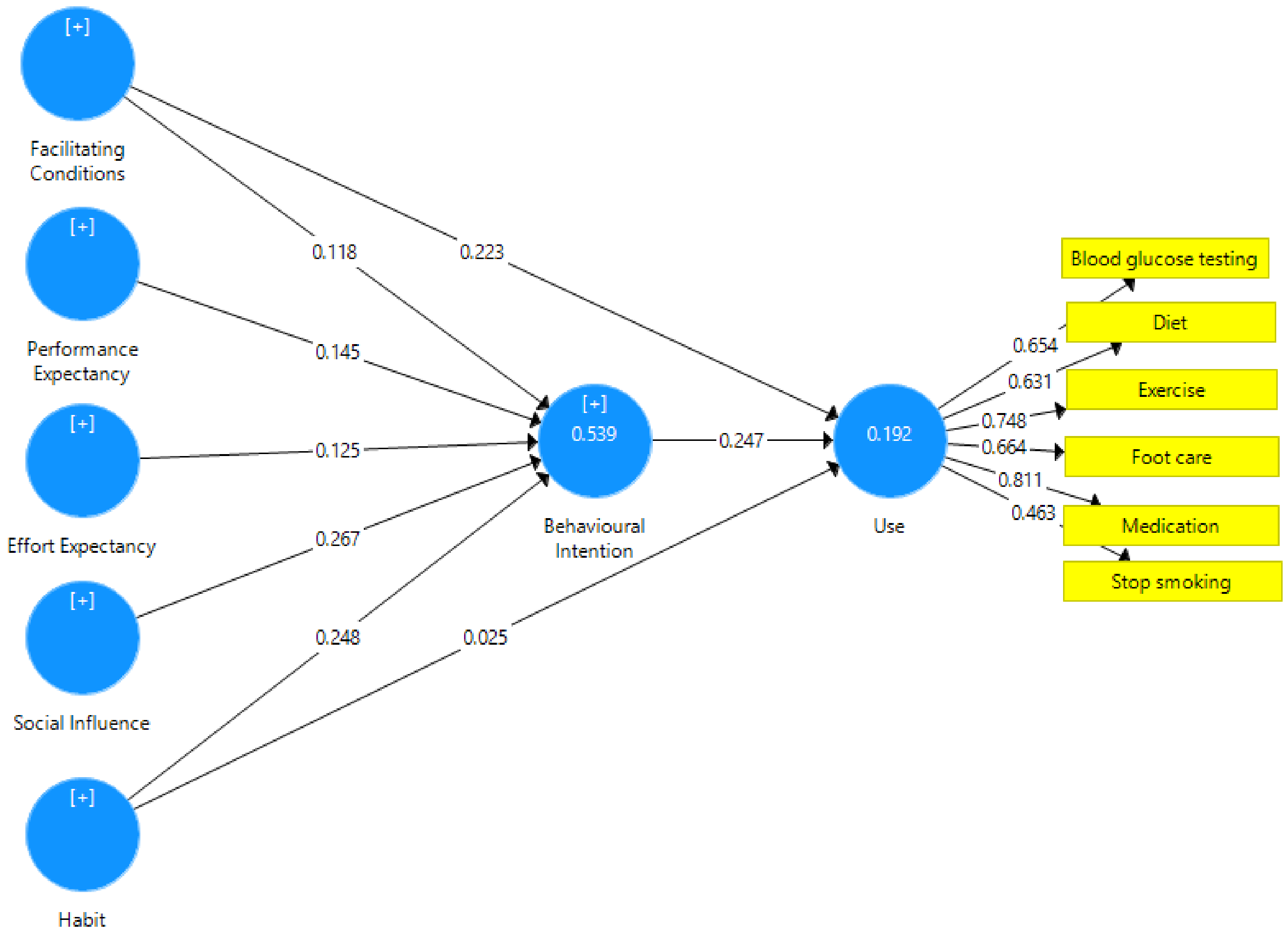


Figure 37 Baseline model path coefficients

As previously stated, R^2 provides a model fit measure (Garson, 2016). The R^2 demonstrates that is the 53.9% of the variance in BI is predictable from EE, PE, SI, FC and habit. Additionally, 19.2% of the variance in use is predictable from FC, habit and BI. Based on Chin, Marcolin and Newsted (2003), the baseline model has a moderate explanatory power for BI and a low explanatory power for the use of m-health applications for self-management.

The use for smoking cessation was the lowest (0.463). Therefore, this variable was deleted: 72.2% of respondents did not smoke. Consequently, 89.1% of respondents did not use a mobile application for this diabetes self-management activity. After deleting this variable, the R^2 for the use variable increased from 19.2% to 19.6% (Figure 38), but this still resulted in a low explanatory power.

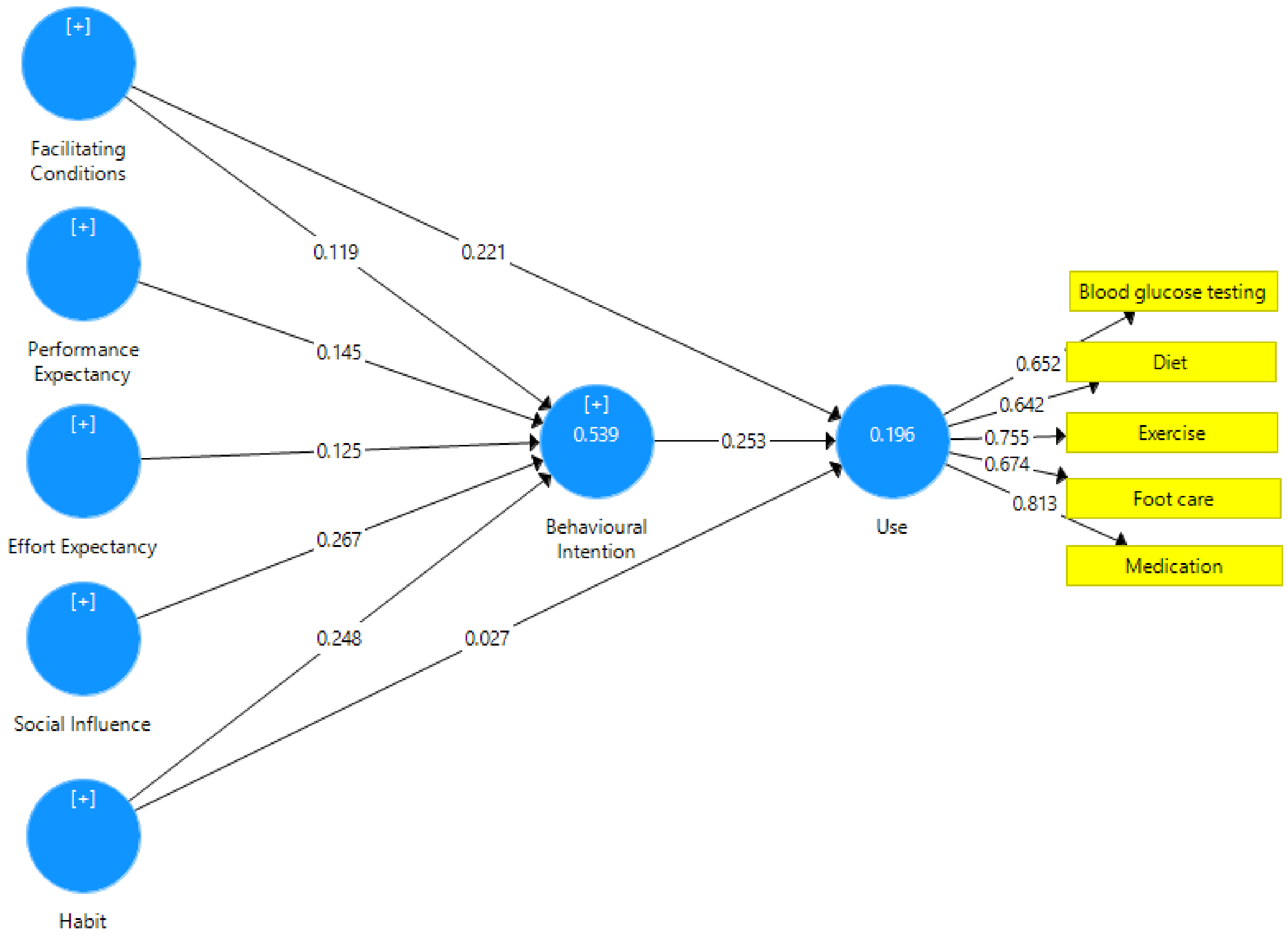


Figure 38 Path coefficients without use for smoking cessation

As stated previously, after determining path coefficients, bootstrapping was run to assess the significance of PLS-SEM results. As a result of the data in Table 31, three hypotheses, namely H2, H4 and H7, were rejected, based specifically on the p-value being less than 0.05, rendering the hypotheses insignificant at a 95% confidence interval.

As evidenced, EE does not have a positive influence on BI; FC does not have a positive influence on BI, and habit does not have a positive influence on the use of m-health apps for diabetes self-management.

Table 31 Hypotheses testing results: baseline variables

Hypothesis		Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P values	Results
H1	Performance Expectancy -> Behavioural Intention	0.145	0.149	0.072	2.017	0.044	Accept
H2	Effort Expectancy -> Behavioural Intention	0.125	0.121	0.070	1.772	0.076	Reject
H3	Social Influence -> Behavioural Intention	0.267	0.265	0.053	5.068	0.000	Accept
H4	Facilitating Conditions -> Behavioural Intention	0.119	0.120	0.061	1.940	0.052	Reject
H5	Facilitating Conditions -> Use	0.221	0.224	0.045	4.962	0.000	Accept
H6	Habit -> Behavioural Intention	0.248	0.248	0.042	5.938	0.000	Accept
H7	Habit -> Use	0.027	0.026	0.041	0.666	0.505	Reject
H12	Behavioural Intention -> Use	0.253	0.253	0.045	5.613	0.000	Accept

Based on these results, the rejected hypotheses were eradicated from the conceptual framework (Figure 39). Moreover, the following hypotheses were not tested due to primary relationships not being significant:

H2a: EE - BI to use m-health apps is stronger for patients with internet access.
H2b: EE - BI to use m-health apps is stronger for patients with higher education levels.
H2c: EE - BI to use m-health apps is stronger for patients with higher income.

H4b: FC - BI to use m-health apps is stronger for patients with higher education levels.

H4c: FC - BI to use m-health apps is stronger for patients with higher income.

H7a: Habit - Use m-health apps is stronger for patients with internet access.

6.16 Novel extensions to the baseline model

As stated in section 6.7, the following hypotheses were tested:

H8: Self-efficacy will have a positive influence on behavioural intention to use m-health applications for diabetes self-management.
H9: Self-efficacy will have a positive influence on the use of m-health applications for diabetes self-management.
H10: Technology anxiety will have a negative influence on behavioural intention to use m-health applications for diabetes self-management.
H11: Technology anxiety will have a negative influence on the use of m-health applications for diabetes self-management.

These extensions and path coefficients are represented in Figure 39. With the inclusion of these variables, the R^2 for BI increased from 53.9% to 55% and the R^2 for use increased from 19.6% to 20.3%. Self-efficacy has a stronger positive influence on BI (0.205) as opposed to use (0.045). Contrarily, there is a weak negative influence of technology anxiety on BI (-0.063) but surprisingly a weak positive influence on use (0.046).

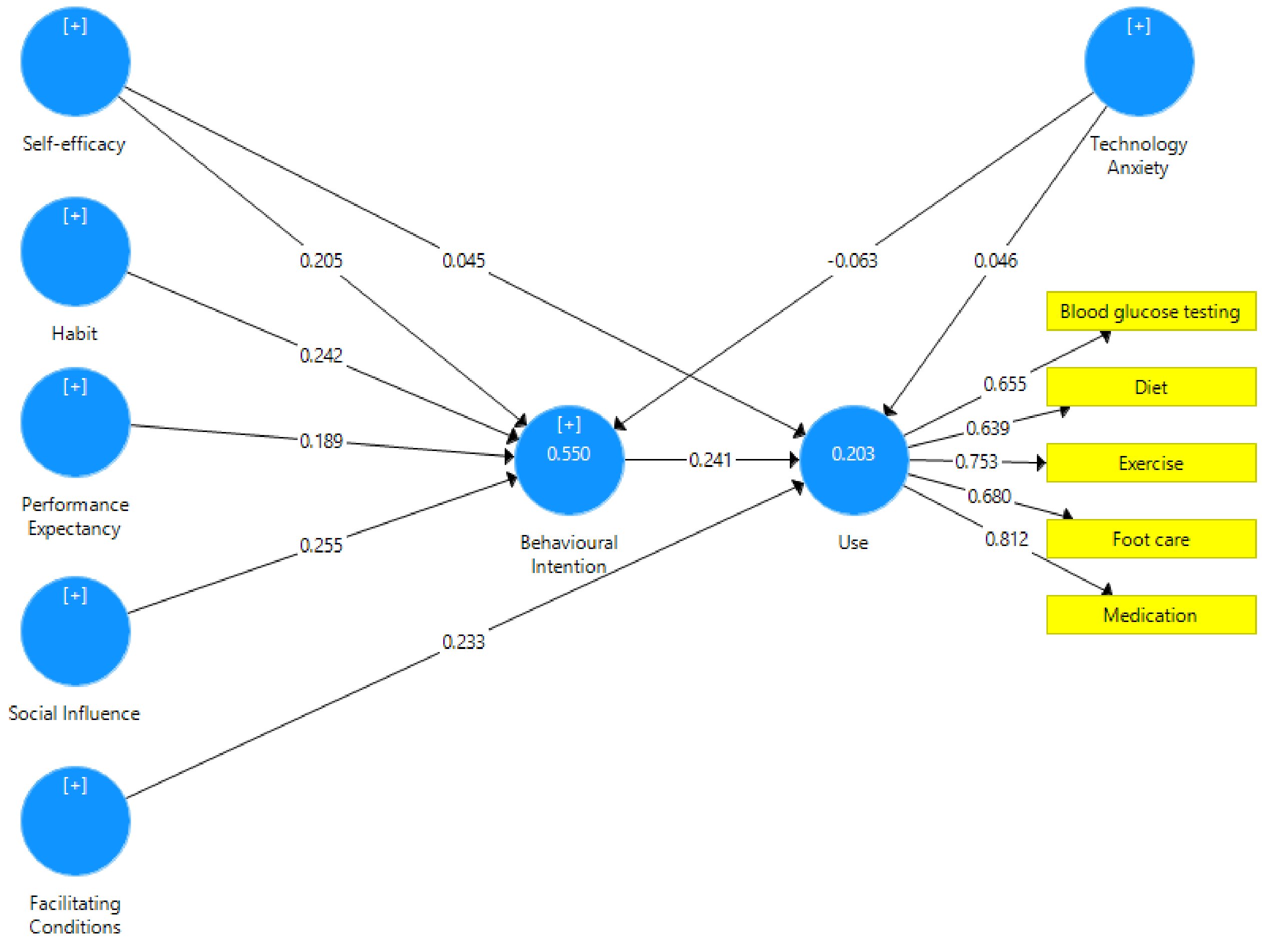


Figure 39 Self-efficacy and technology anxiety variables path coefficients

Based on the bootstrapping results in Table 32, only one hypothesis, H8, was accepted. The relationship is significant – a 95% confidence interval – with a p-value = 0. Self-efficacy, it is clear, has a positive influence on behavioural intention to use m-health applications for diabetes self-management.

Table 32 Hypotheses testing results: new variables

Hypothesis		Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P values	Results
H1	Performance Expectancy -> Behavioural Intention	0.145	0.149	0.072	2.017	0.044	Accept
H3	Social Influence -> Behavioural	0.267	0.265	0.053	5.068	0.000	Accept

	Intention						
H5	Facilitating Conditions -> Use	0.221	0.224	0.045	4.962	0.000	Accept
H6	Habit -> Behavioural Intention	0.248	0.248	0.042	5.938	0.000	Accept
H8	Self-efficacy -> Behavioural Intention	0.205	0.208	0.051	4.051	0.000	Accept
H9	Self-efficacy -> Use	0.045	0.039	0.054	0.841	0.401	Reject
H10	Technology Anxiety -> Behavioural Intention	-0.063	-0.025	0.068	0.918	0.359	Reject
H11	Technology Anxiety -> Use	0.046	0.022	0.053	0.863	0.388	Reject
H12	Behavioural Intention -> Use	0.253	0.253	0.045	5.613	0.000	Accept

Based on these results, the rejected hypotheses were eradicated from the conceptual framework. Additionally, the following hypotheses were not tested due to primary relationships not being significant:

H9a: SE- Use m-health apps is stronger for patients with internet access.
H11a: TA- Use m-health apps is lower for patients with internet access.

6.17 Giving attention to significant emergent relationships

Based on the results in the previous sections, the hypotheses that were not significant, namely H9, H10 and H11, were removed. The significant relationships are graphically represented in Figure 40.

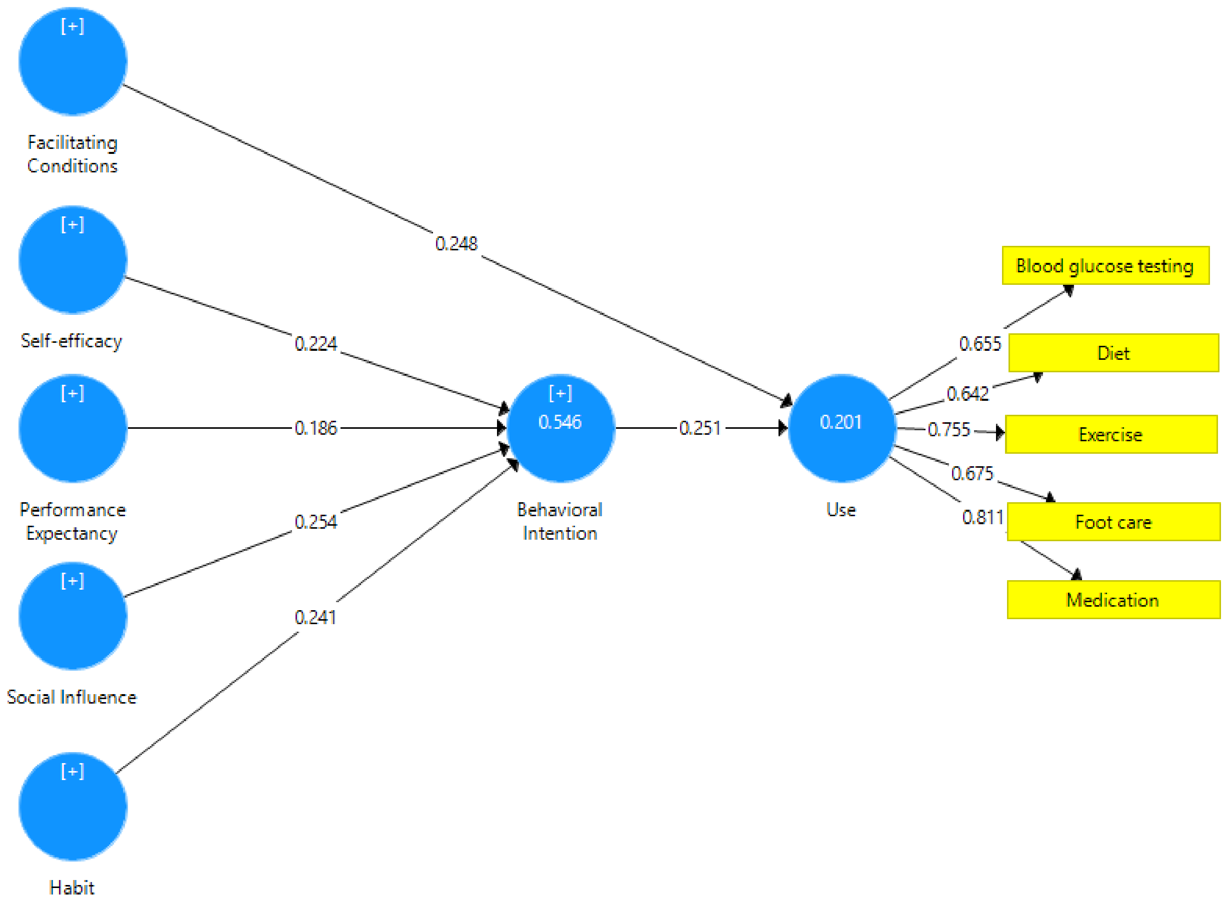


Figure 40 Significant variables and their path coefficients

Table 33 indicates that the variables are significant at a 95% interval as the p values for all the hypotheses were less than 0.05.

Table 33 Hypotheses testing results: significant variables

Hypothesis		Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P values	Results
H1	Performance Expectancy -> Behavioural Intention	0.145	0.149	0.072	2.017	0.044	Accept
H3	Social Influence -> Behavioural Intention	0.267	0.265	0.053	5.068	0.000	Accept
H5	Facilitating Conditions -> Use	0.221	0.224	0.045	4.962	0.000	Accept

H6	Habit -> Behavioural Intention	0.248	0.248	0.042	5.938	0.000	Accept
H8	Self-efficacy -> Behavioural Intention	0.205	0.208	0.051	4.051	0.000	Accept
H12	Behavioural Intention -> Use	0.253	0.253	0.045	5.613	0.000	Accept

The following hypotheses were removed from the conceptual framework because with p values greater than 0.05, therefore not significant at a 95% confidence interval:

H9: Self-efficacy will have a positive influence on the use of m-health applications for diabetes self-management.
H10: Technology anxiety will have a negative influence on behavioural intention to use m-health applications for diabetes self-management.
H11: Technology anxiety will have a negative influence on the use of m-health applications for diabetes self-management.

The following hypotheses were also not tested due to the primary relationships not being significant:

H7b: TA- BI to use m-health apps is stronger for patients with higher education levels.
H7c: TA- BI to use m-health apps is stronger for patients with higher income.

Higher-level and individual-level contextual factors were tested next, on significant variables.

6.18 Higher-level contextual factors

As stated in section 6.9, because location attributes were excluded from the conceptual framework, the only environment attributes, namely internet access, was tested.

Section 6.9.1 specified the hypotheses that would be tested, namely:
H5a: FC- Use m-health apps is stronger for patients with internet access.
H12a: BI- Use m-health apps is stronger for patients with internet access.

The path coefficients in Figure 41 stipulates that internet access has a slightly negative effect (-0.030) on the relationship between FC and the use of m-health apps for diabetes self-management. Yet there is a slightly positive effect (0.046) on the relationship between BI and use.

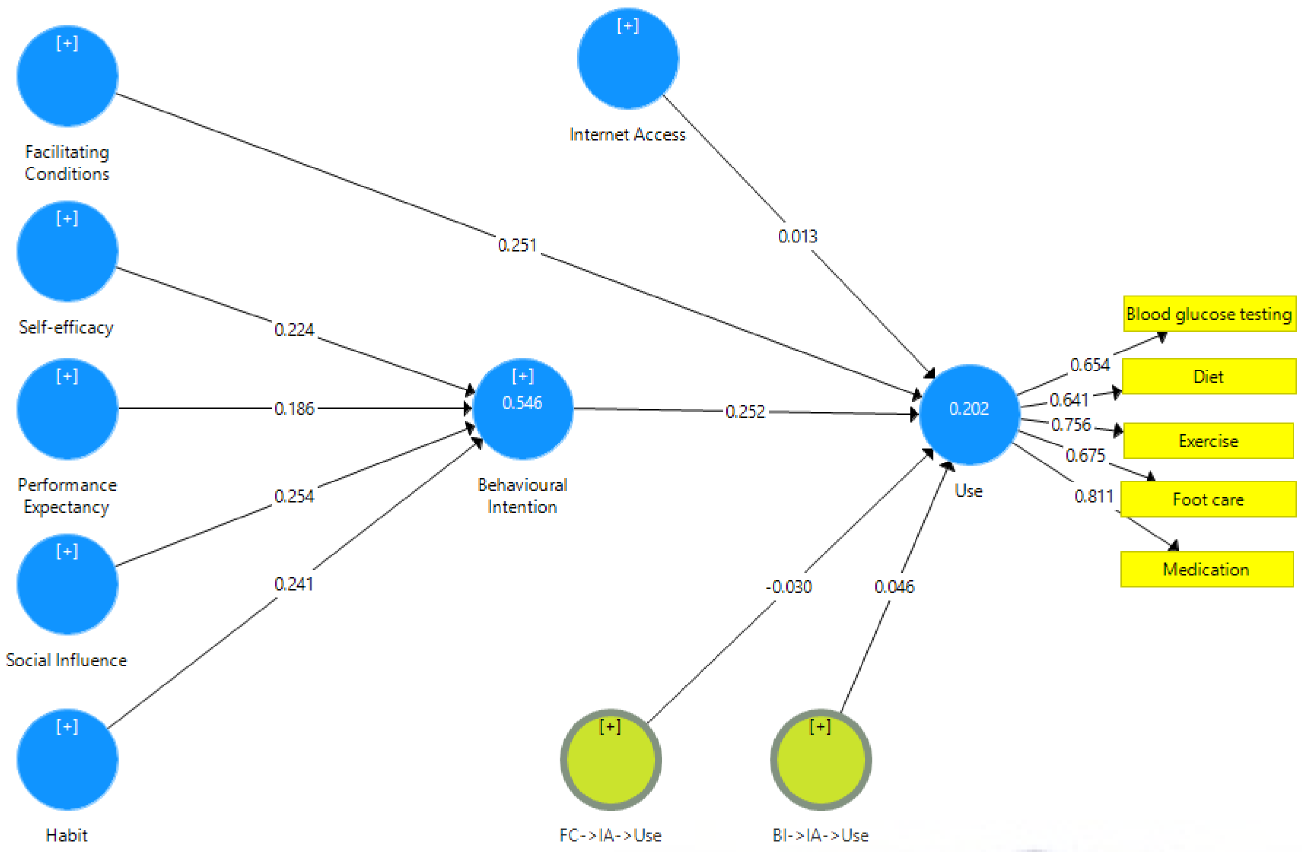


Figure 41 Internet access moderator path coefficients

Bootstrapping results in Table 34 indicated that neither hypotheses were significant at the 95% confidence interval. Therefore, they were both rejected and withdrawn from the conceptual framework.

Table 34 Hypotheses testing results: internet access moderator

Hypothesis		Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P values	Results
H5a	FC-> Internet Access ->Use	-0.030	-0.031	0.048	0.628	**0.530**	Reject
H12a	BI-> Internet Access -	0.046	0.047	0.044	1.051	**0.293**	Reject

	>Use						

6.19 Individual-level contextual factors

Individual-level contextual variables focused on user attributes as technology attributes, namely internet access, was already tested as an environment attribute.

6.20 User attributes

User attributes tested the impact of education and income on the acceptance of m-health apps. The hypotheses tested are indicated below.

6.20.1 Education

As indicated below, four hypotheses; namely H2b, H4b, H6b and H7b, were not tested due to the main relationships being insignificant (section 6.2.1 and section 6.7). These relationships were eliminated from the conceptual framework. Therefore, only the potential moderating effect on significant relationships were tested.

H1b: PE - BI to use m-health apps s is stronger for patients with higher education levels.
~~*H2b: EE - BI to use m-health apps is stronger for patients with higher education levels.*~~
H3b: SI- BI to use m-health apps is stronger for patients with higher education levels.
~~*H4b: FC- BI to use m-health apps is stronger for patients with higher education levels.*~~
H5b: Habit - BI to use m-health apps is stronger for patients with higher education levels.
~~*H6b: SE - BI to use m-health apps is stronger for patients with higher education levels.*~~
~~*H7b: TA- BI to use m-health apps is stronger for patients with higher education levels.*~~

Figure 42 indicates the path coefficients of the four hypotheses tested. Two hypotheses, namely H1b and H3b, exhibited a slightly negative effect on BI. Alternatively, H5b and H6b exhibited a slightly positive effect on BI.

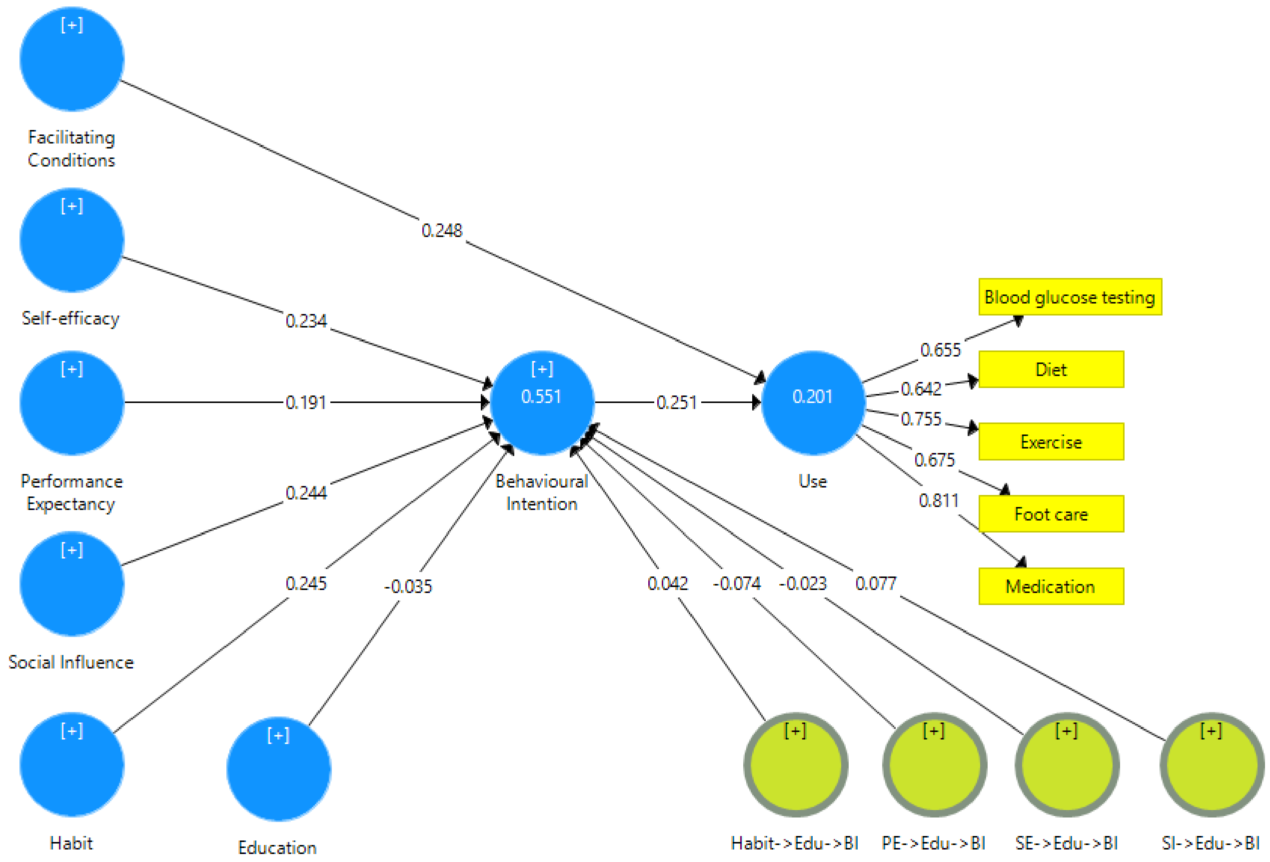


Figure 42 Education moderator path coefficients

Bootstrapping results, presented in Table 35, indicated that none of the hypotheses were significant at the 95% confidence interval. Therefore, each was rejected and removed from the conceptual framework.

Table 35 Hypotheses testing results: education moderator

Hypothesis		Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P values	Results
H1b	PE->Edu->BI	-0.074	-0.073	0.054	1.368	0.171	Reject
H3b	SI->Edu->BI	0.077	0.077	0.054	1.438	0.151	Reject
H5b	Habit->Edu->BI	0.042	0.040	0.039	1.094	0.274	Reject
H6b	SE->Edu->BI	-0.023	-0.020	0.047	0.483	0.629	Reject

Despite none of the hypotheses being significant, it must be noted that the R^2 of BI increased marginally from 54.6% to 55.1%.

6.20.2 Income

As clarified in section 6.10.1.2, the effect of income on the use of m-health apps was tested. As indicated below, three hypotheses, namely H2c, H4c and H7b, were not tested due to main relationships being insignificant (section 6.2.1 and section 6.7).

H1c: PE - BI to use m-health apps is stronger for patients with higher income.
~~*H2c: EE - BI to use m-health apps is stronger for patients with higher income.*~~
H3c: SI- BI to use m-health apps is stronger for patients with higher income.
~~*H4c: FC- BI to use m-health apps is stronger for patients with higher income.*~~
H5c: Habit - BI to use m-health apps is stronger for patients with higher income.
H6c: SE - BI to use m-health apps is stronger for patients with higher income.
~~*H7c: TA- BI to use m-health apps s is stronger for patients with higher income.*~~

The remaining four hypotheses were tested, as indicated in Figure 43. Income has a slightly negative effect on the relationships between PE and BI as well as habit and BI. It has a positive effect on the relationships between SE and BI, as well as SI and BI.

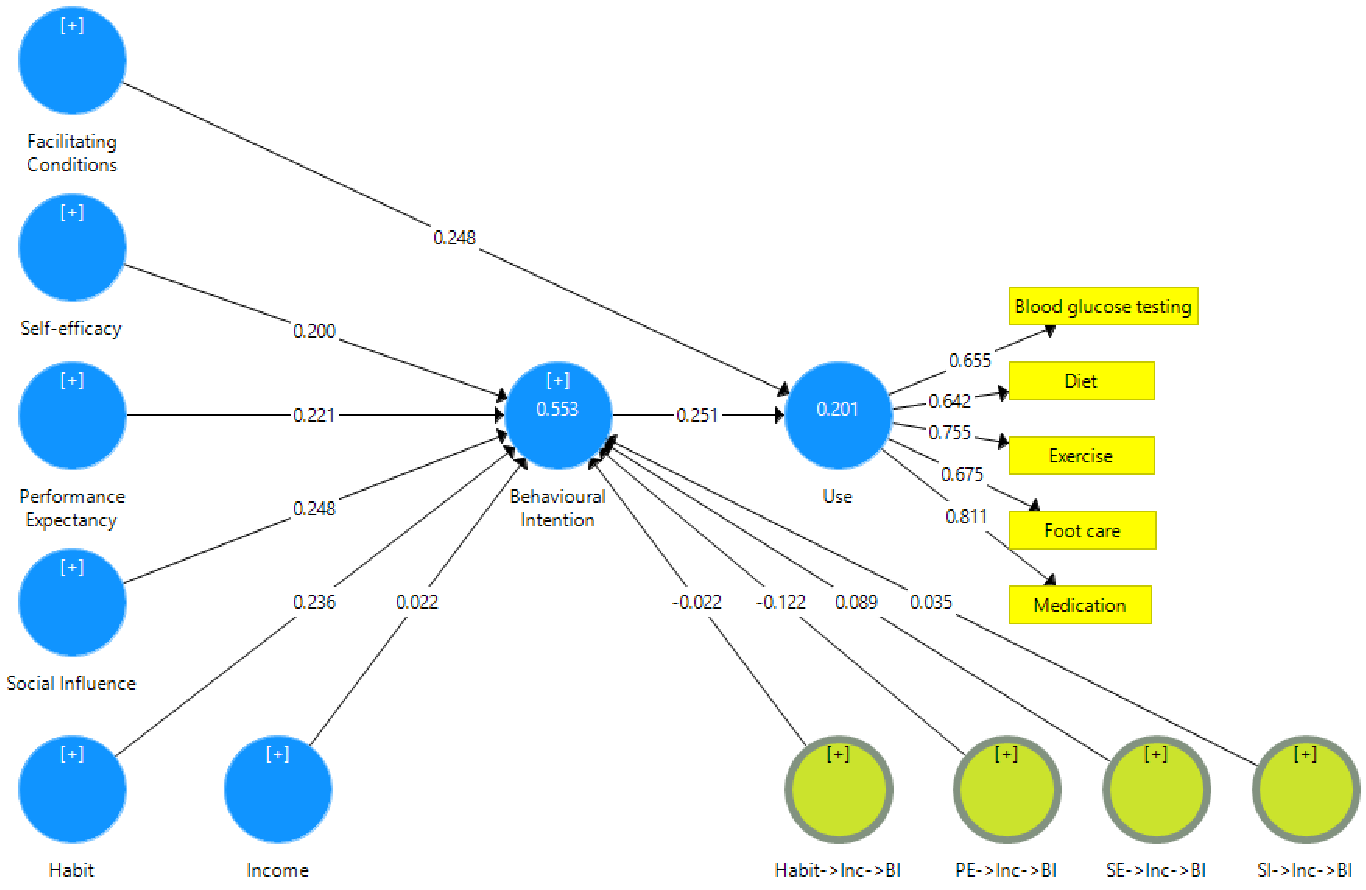


Figure 43 Income moderator path coefficients

The inclusion of the moderator increased R^2 from 0.551 to 0.553. However, the bootstrapping results in Table 36 illustrated that none of the hypotheses was significant at the 95% confidence interval. These hypotheses, consequently, were rejected and eliminated from the conceptual framework.

Table 36 Hypotheses testing results: income moderator

Hypothesis		Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P values	Results
H1c	PE->Inc->BI	-0.122	-0.122	0.062	1.975	0.048	Reject
H3c	SI->Inc->BI	0.035	0.033	0.055	0.640	0.522	Reject
H5c	Habit->Inc->BI	-0.022	-0.021	0.043	0.510	0.610	Reject
H6c	SE->Inc->BI	0.089	0.089	0.051	1.758	0.079	Reject

6.20.3 A novel conceptual framework

Based on the results in the previous sections, the significant variables were collated into the final conceptual framework (refer to Figure 44). The final model represents the contribution to the body of knowledge as it includes the extension of self-efficacy for the use of m-health apps for five diabetes self-management activities: blood glucose testing, diet, exercise, foot care and taking diabetes medication

The path coefficients indicate that the strongest relationship between SI and BI, clarifying that diabetic patients value the opinions of significant others regarding the use of m-health apps. There was also a strong positive relationship between BI and use; however, the R^2 is still low.

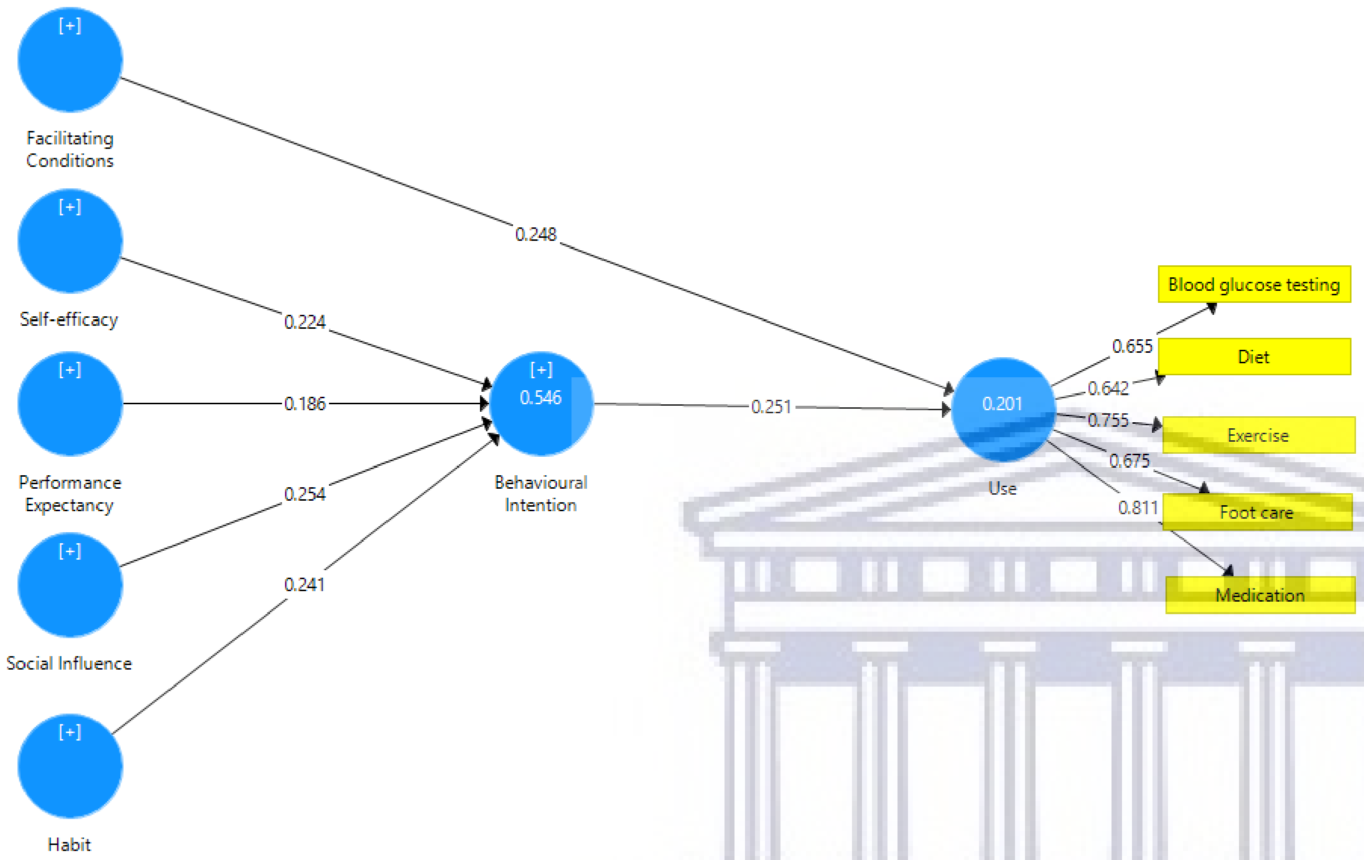


Figure 44 Final model path coefficients

Bootstrapping results as illustrated in Figure 45 proved that all hypotheses were exceptionally significant at the 95% confidence interval. P values of five hypotheses were 0.000. The only exclusion was PE to BI, where the p-value was 0.01. This is, however, still quite significant even though it is the weakest positive relationship (0.186).

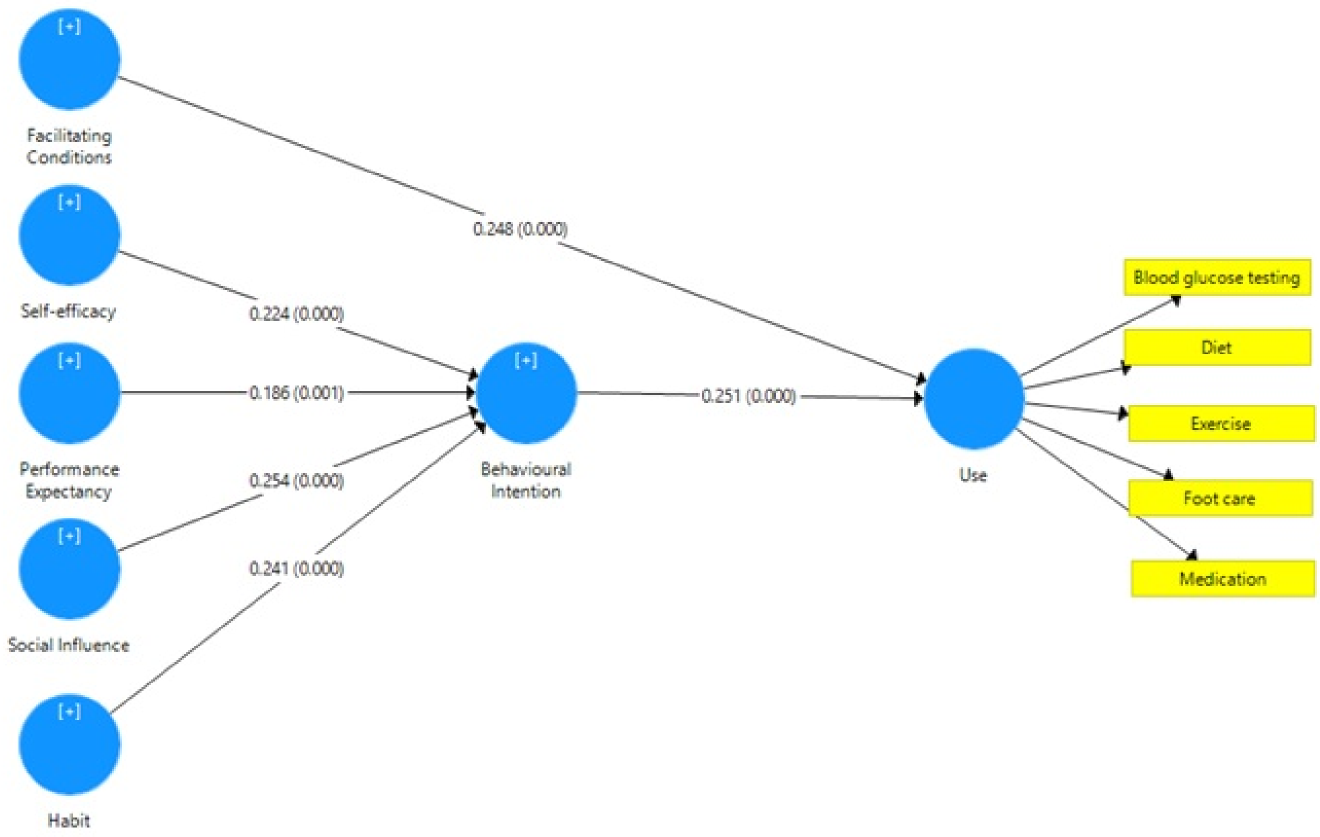


Figure 45 Hypotheses testing results: final model

6.20.4 Implications for using the novel extensions

Given the low levels of m-health app use as indicated in Table 24 and the low R^2 in the conceptual framework (refer to Figure 44), respondents were asked which improvements would entice them to use technology more often. They were provided with a list of potential challenges, based on literature, and asked to select all that applied. They were also provided with the opportunity to add additional information. The results, as seen in Table 37, were as follows:

Table 37 Technology improvements required

Which improvements would make you use technology more often to help improve your diabetes?

		Reference	Frequency	Per cent	Valid Percent	Cumulative Percent
Valid			4	.8	.8	.8
	Cheaper	(Hoque & Sorwar, 2017)	127	24.7	24.7	25.5
	Easier to incorporate into daily life	(Greenwood *et al*., 2017)	74	14.4	14.4	39.9
	Easier to understand	(Ahlan & Ahmad, 2014)	82	16.0	16.0	55.8
	Easier to use	(Ahlan & Ahmad, 2014)	58	11.3	11.3	67.1
	I should be able to give feedback when people design the technology that is supposed to help me	(Isaković *et al*., 2016)	29	5.6	5.6	72.8
	More features	(Bellei et al., in press)	18	3.5	3.5	76.3
	Must take into account my needs and lifestyle	(Isaković *et al*. 2016)	78	15.2	15.2	91.4
	Nothing would make me use technology more	Author	44	8.6	8.6	100.0
	Total		514	100.0	100.0	

The largest percentage (24.7%) acknowledged their desire for technology to be cheaper. This was followed by the need for applications to be easier to understand and to take into account their specific needs and lifestyles.

6.21 Chapter summary

The chapter began with the demographic analysis of the data, defining hypotheses to be tested in the conceptual framework that was an adaptation and extension of Venkatesh *et al.*'s (2016) latest Multi-Level Framework of Technology Acceptance and Use.

Quantitative data, collected from 541 diabetic respondents residing in South Africa's Western Cape, demonstrated that four variables – performance expectancy, social influence, habit and self-efficacy – had a positive influence on behavioural intention (R^2 = 54.6%). Additionally, facilitating conditions and behavioural intention had a positive influence on use for diabetes self-management activities, excluding smoking cessation (R^2 = 20.1%). Income, education and internet access did not prove to have a moderating effect on any of the significant relationships.

The chapter concluded with the implications for the implementation of m-health interventions. The next chapter concludes with a final overview.

CHAPTER 7 – Discussion and conclusion

Progress in technology allowed me to have a continuous glucose monitor (CGM) sensor inserted surgically under the skin in my arm. It lasted for six months, so I did not have to insert continuous glucose sensors into my arm every week. It vibrated to notify me when my blood sugar levels dipped below the target glucose values that I inserted into the application on my phone. The application showed my blood glucose trends, generating reports that could be sent to my health team. If I had an Apple phone, then it would even notify the people whom I had pinpointed as part of my emergency team that I was in trouble when my blood sugar levels went too low. Alas, my Android phone did not have this functionality (brand bias). However, it also meant that I had to carry my mobile phone around with me ***all the time****! With my phone comes work, so when I checked my glucose levels, I checked my emails and did some work. There was no downtime. I couldn't switch my phone off and I'm too much of a 'workaholic overachiever' to not open the work emails as they appear. So another mobile application, no thanks! I'll instead use the graphs on my insulin pump and insert weekly CGM that my medical aid won't cover as part of my chronic medication benefit. So let me rather spend R2000 for CGM per month out of my medical savings account and run out of medical saving in a few months so that I don't have to use a mobile application but won't go into a hypoglycaemic coma and die! My medical savings or my life?*

7 Discussion and conclusion

This chapter provides a summary of the findings concerning the answers to the posed research questions. The chapter addresses the problem statement explicitly, discusses the process and nature of novel construct development that emerged from the synthesis of results culled from a rigorous enquiry into the three critical realism domains. The chapter, therefore, contains a clear characterisation of the contribution of knowledge to the field of Information Systems, limitations related to that claim, recommendations for applying the novel framework, and finally, points the way toward taking this research trajectory further.

7.1 Reconsidering the research problem

This thesis aims to identify, study and thereby understand the factors that influence the acceptance and use of m-health apps for diabetes self-management in the Western Cape province of South Africa. The main outcome of the study is an adaptation/extension of conventional frameworks for technology acceptance and use into a novel Multi-Level Framework of Technology Acceptance and Use (MultiTAU). This novel adaptation of TAU incorporates individual and higher-level contextual factors. Thus MultiTAU comprises a novel conceptual framework, with this chapter arguing that it contributes to the body of knowledge given that it extends the extant theories in relation to technology acceptance and use.

The research problem for the study is premised on *fifty* key observations based on a critical realist assessment of the environment in which the problem resides. In summary, non-communicable diseases (NCDs) are the leading cause of death globally, with diabetes, in particular, the leading cause of death in Western Cape. Diabetes control is lower among racial and ethnic minorities, and especially those with low socioeconomic status. The demographics of the Western Cape reflect the socioeconomic plight of a substantive population; the situation is bleak indeed. Additionally, segments of the Western Cape population experience technological forms of exclusion on tops of educational and income inequalities. The resulting internal (provincial) digital divide is significant. These factors contribute to the fact that despite the availability of free mobile apps to assist with diabetes self-management, usage is, and by all indications will remain, low.

7.1.1 Discussion of key findings

This section, in summarising the key findings related to answers of the research questions, considers each respective set of findings in light of relevant and recent literature. To answer research questions, the current use of m-health apps and challenges to m-health app use was investigated in efforts to synthesise the findings into a novel technology framework of technology and use.

The literature review commenced by examining ICT4D literature to more clearly understand ICT and its relationship to human development, referring to life expectancy and particularly SDG 3: the achievement of healthy lives and the promotion of well-being for all at all ages. With the escalating number of patients with diabetes and limited resources in LMICs, ICT4D literature recognises the import of research to expressly consider *context*. Context includes factors such as socioeconomic conditions, culture, demographics, politics, ICT policy framework and ICT diffusion. We contend that contextual factors also influence diabetes self-management.

Results indicate an existing lack of self-management activities performed, resulting in complications and increased hospital admissions, all of which may ultimately lead to mortality. This is evident with diabetes as the leading cause of death in the province (American Diabetes Association, 2014; Statistics South Africa, 2016).

The findings also indicate a potential negative impact on the achievement of the SDG 3, as well as the South African Strategic Plan for the Prevention and Control of NCD, and the South African national development targets set for 2030. However, all of this can be prevented, or the onset can at least be delayed, through early diagnosis, treatment, management and control (Kengne & Sayed, 2017). Additionally, a study by Mukong, Van Walbeek and Ross (2017) provides evidence that health inequalities are highly prevalent within marginalised communities. The Cape Flats area, where the majority of our respondents reside, is replete with marginalised communities (Western Cape Government, 2017a) exhibiting low health capabilities.

Literature states that strategies for improving healthcare need to take into consideration the 'communication style' preference of patients, as well as patient literacy and numeracy levels. Additionally, cultural barriers to care should be addressed and community involvement should be supported, provided this is feasible (American Diabetes Association, 2015). This study's results reveal that culture impacts diabetes self-management, as respondents' diet was affected. However, despite literature suggesting that culture impacts the acceptance and use of m-health (Müller, 2016), this was not significantly supported by findings herein.

It was determined, however, that preference is for the use of a glucose meter, as 42.7% of respondents use this device. Despite advances in glucose meter technology allowing it to connect to a compatible mobile device, 20% of respondents did not have the skills to complete the tasks or had glucose meters still without that functionality. The lack of technology literacy does impact m-health acceptance and use. Therefore, it makes perfect sense that providing e-skills is a critical component of South Africa's National e-Strategy, where comprehensive skills development programmes are envisaged to improve the uptake and usage of ICT in society.

Recent studies indicate that multiple national initiatives to improve the health of older people have been only marginally successful (Werfalli *et al*., 2019). Therefore, future interventions must be designed to take into consideration older users with (possibly) lower technology literacy and with designs compatible with ease of use by an ageing population segment.

7.2 Discussion of research questions in light of findings

This section discusses research sub-questions and their corresponding findings. The results from this study are considered in light of relevant literature to highlight similarities and differences.

7.2.1 M-health apps for diabetes self-management and developmental goals

Literature relating to the use of ICT to elevate diabetes self-management highlights the use of m-health applications. However, there is limited evidence concerning the effectiveness of m-health on clinical and behavioural outcomes of patients despite the enlarging use of mobile applications for chronic disease management. Prominent theories and models for technology acceptance and use were critiqued herein. This thesis examines the literature related to theories and models of technology acceptance such as TAM, TRA, TPB, DOI and UTAUT, including the novel MultiTAU framework, all of which can be utilised to identify the determinants of acceptance and use of m-health apps for diabetes self-management, and how this can accelerate the achievement of developmental goals in the area of health. Due to our investigation, the novel MultiTAU emerged to address UTAUT critiques with the inclusion of *contextual* factors that are substantively highlighted in the ICT4D literature. MultiTAU, including individual and higher-level contextual factors, emerged as the theoretical lens to investigate the research questions and subquestions.

A critical realism paradigm by employing epistemic relativism to arrive at MultiTAU, the novel contribution, was employed. The high-level framework showing the applied research methodology was presented in Table 2. The critical realism paradigm includes three overlapping domains: the real, the actual and the empirical.

The domain of real refers to structures and mechanisms that are enduring and lead to the generation of events (Mingers, 2004). Structures in this study refer to the current level of diabetes self-management. It was critical to assess the impact on health due to its implications on developmental goals. The measurement of diabetes self-management activities used the Summary of Diabetes Care Activities (SDCA).

Results indicate that the level of self-management activities are low. Respondents admitted they took their recommended diabetes medication on average 5.60 times per week. This finding demonstrates that most respondents are taking their medication, although not at the required consistency of taking it *daily*. Also, they did not take the medication at the recommended dosage (mean=5.27).

It is also evident that the level of blood sugar testing recommended by health care providers is higher, as this mean was the lowest of all activities (2.26). These findings are likely a key indicator of the high level of diabetes complications (50.5%). Risk factors investigated included diet, physical activity and tobacco use. More than half of the respondents last smoked more than two years ago or have never smoked. However, 21.7% of them indicated that they had smoked that day. For the ones who smoked, 17.5% indicated that they were counselled about smoking cessation or referred to a stop-smoking programme. This bodes well in reducing smoking as a risk factor. However, due to the low levels of self-management activities performed, and the severity of diabetes complications, there is a negative impact on SDG 3 as respondents are at a low level of health capability.

Performance expectancy, effort expectancy, facilitating conditions and social influence all had a positive influence on behavioural intention to use ICT for diabetes self-management. These findings are supported by the literature (Venkatesh *et al.,* 2003, 2016; Mutlu & Der, 2017). Another study by Hoque and Sorwar (2017) indicates that performance expectancy, effort expectancy and social influence have a significant impact on users' behavioural intention to adopt m-health services.

According to our findings, effort expectancy had the most significant influence on behavioural intention. There is also strong support in the literature that behavioural intention is a strong indicator of use behaviour (Venkatesh, Thong & Xu, 2016). However, it was found that BI did not translate into use in this context, as almost 70% of the respondents do not use ICT such as m-health apps to manage their diabetes. This may point to weaknesses in the ecosystem in which diabetic patients live. In particular, the contextual factors may not be conducive to convert intention into use.

These findings cumulatively support the view that despite access to the internet via prepaid mobile phones, the use for health activities is low, and especially so for older patients (Li *et al.*, 2017). Research in China supports the finding that attitude can be used to predict intention to use mobile health services for persons who were over 40 (Deng, Mo & Liu, 2014). This is in stark contrast to findings that indicate a need for interventions due to the low level of self-management activities and resultant complications (section 4.4.1). These findings suggest a negative impact on the achievement of developmental goals such as SDG 3 and related national policies like South Africa's NDP 2030.

Respondents also indicated that they used other mechanisms, e.g. glucose meters (42.7%). Despite the fact that glucose meters now have improved functionality, generating reports to be shared with health care providers, 28.6% of respondents indicated that they did not download reports with readings from their glucose meters. This is linked to the result that 20% of respondents lacked the skills to complete the task, or simply have glucose meters without that functionality. *Such findings are not represented in any other study*.

There have been several recent worthwhile studies on diabetes in South Africa (Stephani, Opoku & Quentin, 2016; Kengne & Sayed, 2017; Werfalli *et al.*, 2019). However, none of these studies employed SDCA as a measurement or combined diabetes self-management measurement with access to ICT and the use of m-health.

Our findings also indicate mechanisms were indeed in place because respondents had access to the internet. However, only 31.6% of respondents were using technology every day. The use of m-health apps daily could deliver beneficial information and mechanisms for diabetes self-management, as respondents could use functionalities such as reminders to take medication and exercise.

The domain of real indicated that despite diabetes self-management activities (structure) being low, ICT access (mechanisms) are in place; *yet this did not translate into the use of ICT*, such as m-health for diabetes self-management (event). These findings implied a negative impact concerning SDG 3, as respondents did not perform self-management activities, resulting in diabetes complications. These findings supported the need to investigate the contextual factors and challenges for m-health acceptance and use, particularly for diabetes self-management.

7.2.2 Contextual factors that influence diabetes m-health app acceptance and use

To understand the contextual situation in the Western Cape of South Africa, the literature review in Chapter 2 concluded with a review of the pertinent challenges for the use of m-health apps for diabetes self-management (see section 2.6). From this, access and affordability were identified as a significant challenge. There is also a need for interventions to effectively adapt to local contexts with diverse populations that have significant educational, technological and income inequalities.

Therefore, based on the literature, the following factors were considered:

- Higher-level contextual factors:
    - environmental attributes - access and affordability were identified in the literature review;
    - location attributes - including culture as the literature indicates that cultural beliefs are a key factor for technology acceptance and use;
- Individual-level contextual factors:
    - user attributes - this research included education and income as key factors for diabetic patients who use technologies to assist in performing self-management activities; and
    - technology attributes.

The mechanisms of access to ICT, as well as the use of m-health for diabetes self-management, were evaluated. In the empirical study conducted in the domain of real, respondents indicated that they had access to the internet, as 37.4% used prepaid air time for internet access on their mobile phones, while 23.1% of respondents used Wi-Fi. However, 15.7% of respondents indicated that they do not have internet connectivity. This low internet usage, common in South Africa where telecommunications are priced amongst the highest in the world (Gillwald, Mothobi & Rademan, 2017), could certainly impact on the use of m-health apps for diabetes self-management. The highest percentage of respondents (31.6%) indicated a daily use of technology; yet semi-structured interviews in the domain of actual revealed that internet usage was for social media such as Facebook and WhatsApp, not m-health or health-related activities.

Communities in developing countries have limited resources and thereby limited access to various technologies and infrastructure (David & Rafiullah, 2016). Affordability and accessibility are therefore obstacles to genuine access and usage (Akhlaq *et al.*, 2016; Beratarrechea *et al.*, 2016). Note, however, that this study has found that mechanisms exist in the Western Cape context, as respondents have access to various forms of ICT, whether a glucose meter, mobile phone or computer.

However, environmental attributes revealed that the economic conditions which the participants' experience restrict the use of expensive m-health solutions. Consequently, future m-health interventions, to adapt to this economic reality, must consider cost-effective methods to attract diabetic patients residing in low resource communities. This is supported by a study of m-health usage among patients and health workers in rural South Africa which found that the "use of the websites and social media was intermittent due to lack of financial ability to afford airtime" (Anstey *et al.*, 2018:139). Therefore, the use of zero-rated and back-billed services, where the cost is absorbed by South African mobile operators or some other socially-minded entity, will be beneficial in rendering m-health services more accessible to lower-income South African diabetics.

The remaining contextual factors are discussed in further detail below as evidence indicated that these posed challenges for the acceptance and use of diabetes self-management m-health apps.

7.2.3 Challenges for the use of m-health apps for diabetes self-management

The findings from the domain of real (see section 4.7), and the need to identify events that can either be observed or unobserved and that are generated when mechanisms are activated (Mingers, 2004), show that events put the low level of m-health app use into perspective. It was, therefore, necessary to analyse the challenges for m-health apps use in the domain of actual (as in Chapter 5). This domain employed qualitative methods in the form of semi-structured interviews to unpack such challenges. Findings expressly identified the novel MultiTAU variables beyond and above those included in the baseline model (EE, PE, SN, and FC), to include higher-level (environmental and location attributes) and individual-level contextual factors (user attributes and technology attributes) for unpacking potential challenges to technology acceptance and use.

Qualitative findings revealed that cultural factors affecting technology acceptance and use include participant perceptions: that mobile technologies will be of no use, the mistrust of technology as a foreign concept, and the preference for face-to-face interaction with medical staff. This stems from a lack of participant awareness concerning the benefits of m-health applications, or of a ‘blended’ approach in general. The study findings are supported by findings proving it is critical to consider culture. For example, some rural, low-income people with increased weight do not recognise this as a problem as this heaviness is accepted as part of their culture (de Jager & Van Belle, 2014); however, obesity is a clear and present risk factor for diabetes. Despite the qualitative findings and literature indicating that culture should be examined, respondents in the domain of empirical indicated that their culture *did not* impact their acceptance and use of diabetes self-management m-health apps. However, it appears that culture *does* impact diabetes self-management activities.

Additionally, the findings revealed a lack of technological literacy, as respondents were either unaware that m-health technologies were available or were not technologically literate in terms of its effective use. The work of de Jager and Van Belle (2014) supports these research findings, strongly advising that language, literacy and techno-literacy should be considered. This finding is not peculiar to this sample population, as it is also evident in rural communities where patients did not know which health information to search for or even where to search (Anstey *et al.,* 2018). This highlights the imperative to boost technological literacy. It can only be deduced that the incorporation of technology literacy programmes into the health care system could benefit, in particular, older patients with diabetes. Despite e-skilling the nation as an integral part of the South African National e-Strategy, the operationalisation of this will require substantive funding.

This research has identified technological challenges pertaining to the access and usage of technological devices and the availability of an internet connection, which yet reveals a disparity with the South African National e-Strategy that aims to provide universal access. Our South African reality is that the majority of its population are surrounded by universal access they simply cannot afford; hence, it is not *truly* accessible.

The results also indicated that while ICT is accessible and is being used to some extent, it is not actualised to the extent that it has become universal. M-health apps have the potential to expand within this region, especially among younger, more tech-savvy patients but this may potentially further increasing the grey divide. However, many respondents indicated that they did not believe that m-health apps would assist them in achieving better health; performance expectancy was low, especially for older patients. However, in the domain of real, performance expectancy had a significant effect on ICT usage for diabetes self-management with respect to behavioural intention. The domain of empirical finding is contrary to a study in Bangladesh which shows that performance expectancy predicts citizens' behavioural intention for m-health (Dwivedi *et al.*, 2016) in another LMIC context.

Technology anxiety and a lack of self-efficacy were also identified as potential reasons for the low usage. Triangulation from the domain of real and the domain of actual ensured the reliability of results. All quantitative results were supported by qualitative results; no differences in findings were noted (as shown in Table 26). Therefore, these factors were synthesised into the conceptual framework and will be discussed in the following section.

7.2.4 Synthesising factors that influence the acceptance and use of m-health apps for diabetes self-management into a framework of technology acceptance and use

The domain of empirical (discussed in Chapter 6) resulted from events that had been observed and experienced (Mingers, 2004). A conceptual framework, based on MultiTAU, was developed and tested. Partial least squares structured equation modelling verified the relationships between the variables and moderators identified from the literature, the domain of real and the domain of empirical.

Six variables were significant, with an array of influence: performance expectancy, social influence, habit and self-efficacy had a positive influence on behavioural intention (R^2=54.6%). Additionally, facilitating conditions and behavioural intention had a positive influence on use for diabetes self-management activities, excluding smoking cessation (R^2=20.1%).

The effect of self-efficacy on behavioural intention and the use of m-health applications for diabetes self-management was not significant in this study. This finding is supported by a study on clinician adoption of health information systems in Cameroon where self-efficacy has no direct significant effect on health information systems adoption in that context (Bawack & Kala Kamdjoug, 2018).

The relationships between technology anxiety and behavioural intention as well as the between technology anxiety and use were not significant in this research. However, technology anxiety was found to influence the adoption of a mobile chronic disease management system in China (Zhu *et al*., 2018). It should be noted that the Chinese and South African contexts, in terms of access to internet and GDP, are vastly different; these differences, then, may be a possible reason for the differences in results.

Education did not prove to have a moderating effect on any of the significant relationships. As stated in Table 30, the educational levels of respondents reflect that the majority (69.4%) have at least a Grade 12 education. Section 6.10.1.1 clarified that the remaining 30.6% of respondents with lower educational levels may be the older patients who have not completed Grade 12. This could be the reason why education did not moderate relationships, as most respondents were not uneducated. However, technological literacy should be tested separately in future as respondents indicated a lack of e-skills (section 5.4).

Income did not have a moderating effect on any of the significant relationships, yet the demographics indicated a significant difference in income with the highest percentage of respondents (23.5%) earning more than R12 000 per month while the biggest proportion of respondents (46.4%) earning less than R4 000 per month. Research indicates that there are disparities in the use of an m-health medication adherence intervention for low-income adults with type 2 diabetes and those with lower health literacy (Nelson, Mulvaney *et al.*, 2016); this, however, was not evident in this research.

Despite testing the relationships between twelve variables, connecting the literature and findings from the domain of real and actual, the conceptual framework did not provide a high level of predictability of m-health usage for diabetes self-management. It is still believed that the discoveries herein contribute to the body of knowledge as a recent systemic review on mobile apps, stated by Chib and Lin (2018:90), are "incorporating technological inputs, theoretical mechanisms and health outputs" because such studies are rare. This research explores mechanisms, structures and events for diabetes self-management activities e.g. diet, exercise and blood glucose monitoring (health outcomes at an individual level), thereby increasing the research in areas that are currently lacking.

7.3 Process of knowledge creation

As stated previously, critical realism makes use of epistemic relativism. Epistemic relativism posits that knowledge is contextually, culturally and historically situated (Saunders, Lewis &

Thornhill, 2009). Critical realism also argues that new knowledge is created in the transitive domain, as it is dependent on humans (Zachariadis, Scott & Barrett, 2013). This research examined existing literature and identified gaps (section 2.6).

Prominent gaps in the literature, grouped in Table 4, included the following:

- **Context**: Providing ICT access to the poor will only achieve lasting and sustainable benefits if ICTs are appropriate to the local needs and realities.
- **Acceptance and use of m-health applications for diabetes self-management:** Little evidence was found concerning the likely uptake, or best strategies for engagement, efficacy, or effectiveness. There is a need to develop behavioural change interventions that are culturally-informed.
- **Impact of m-health acceptance and use on the achievement of development goals.**
- **Challenges**:
    - Higher-level contextual factors
    - Individual-level contextual factors.

The gaps identified in the literature were investigated applying a critical realist paradigm. The process to create new knowledge is visualised byFigure 46.

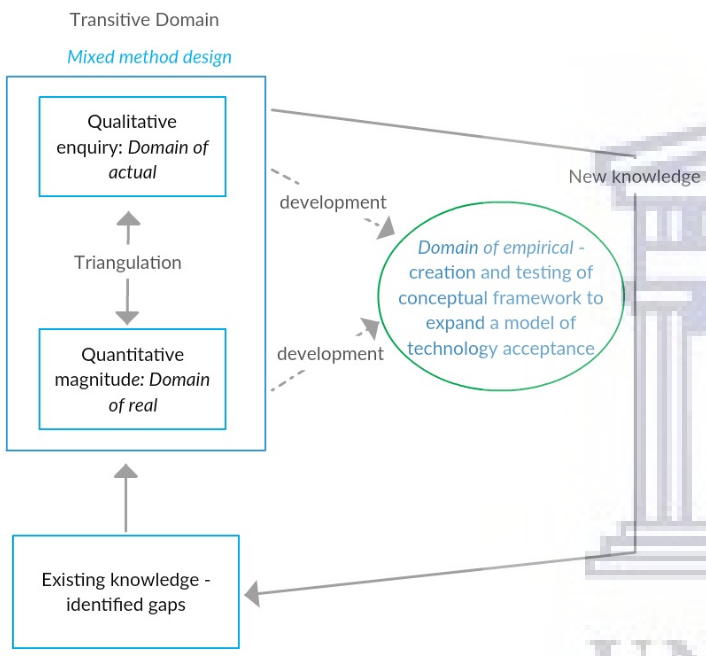


Figure 46 Transitive domain of critical realism for knowledge creation
Adapted from Zachariadis, Scott & Barrett (2013:5)

The research process described within this thesis employed mixed methods as it is argued that a combination of quantitative and qualitative methods could lead to a more explicit understanding of a complex, intricate problem domain, and addresses the criticisms from using a purely positivist or interpretivist paradigm (Venkatesh, Brown & Bala, 2013; Heeks & Wall, 2018). This is based on the fact that using only one of type method is inadequate to address the complexity evident in socio-technical research (Cresswell, 2014). It is argued that a research inquiry using a mixed methods approach can uncover more comprehensive factors and their interrelationships (Cresswell, 2014). This assisted in developing complementary and divergent views to extend, discover and develop the theory of technology acceptance and use (Venkatesh, Brown & Bala, 2013). Additionally, it helped to undercover other generative mechanisms, i.e. the use of glucose testing machines that could contribute to the low level of m-health usage for diabetes self-management.

Based on Heeks and Wall (2018), health and adoption are two complex issues; therefore, the research process triangulated mixed methods. The use of mixed method triangulation design is supported by Wynn and Williams (2012) who contend that multiple methods assist in causal analysis.

Table 5 identified the structures, mechanisms and events investigated to answer the research questions first outlined in section 1.4. The domain of real employed quantitative methods to investigate the current level of diabetes self-management (structure), the current level of access to ICT (mechanism) and the current use of ICT for diabetes self-management (event). The broader ICT term was used in this domain as it is possible to use alternate ICT options for diabetes self-management. Investigating ICT allowed for the discovery of other mechanisms besides m-health apps.

The use of triangulation provides expanding views as qualitative data (the domain of actual) can compare and contrast, interrelate, and validate quantitative data (the domain of real). The domain of empirical (quantitative) conceptual framework was developed from the findings in the domain of real and the domain of actual. The adaptation of the MultiTAU model by including individual and higher-level contextual factors for resource-constrained environments into the novel conceptual framework is a contribution to the existant body of knowledge as it extends a model of technology acceptance and usage.

7.4 Research contribution to knowledge creation

It is hoped that the adapted MultiTAU model offered by this thesis provides the reader with a deeper understanding of the determinants of technology acceptance and use of m-health apps, particularly for diabetes self-management, and in particular, how this may assist in the achievement of developmental goals for patients in the Western Cape, South Africa. The contribution, the MultiTAU model, can be viewed in three complementary ways: theoretical, methodological and practical.

7.4.1 Theoretical aspects of the contribution

The theoretical aspects of the MultiTAU model apply to the ICT4D-learning technology acceptance and use body of knowledge. Based on the literature reviewed on m-health studies in South Africa, this is the first study to utilise and apply the MultiTAU model in the context of the Western Cape to determine factors that influence m-health use for diabetes self-management. This study offers and applies the MultiTAU model as a theoretical lens that includes high-level contextual factors (environmental and location attributes) and individual-level contextual factors (user and technology attributes) specific to the Western Cape.

The study validates and confirms the significant role of self-efficacy and highlights that technological anxiety, education, income and internet access *do not* affect the acceptance and use of m-health apps for diabetes self-management in the Western Cape. In the domain of empirical, this study establishes significant relationships among the key variables within the Western Cape context.

7.4.2 Methodological aspects of the contribution

The use of positivism is prevalent in technology acceptance and use literature (Venkatesh, Thong & Xu, 2016). Interpretivism is used to understand the perceptions in qualitative studies investigating user perceptions of mobile health apps (Peng *et al*., 2016) and user experiences of m-health apps to facilitate self-care (Anderson, Burford & Emmerton, 2016). The use of the critical realist paradigm with mixed methods, used to manifest the MultiTAU model, makes a methodological contribution by identifying factors such as ICT, organisational, environmental and social factors, which have played a causal role in the low level of m-health usage for diabetes self-management in the Western Cape context.

7.4.3 Practical aspects of the contribution

The cost-effective and practical recommendations for 'lensing' with the MultiTAU model provided to the Department of Health (refer to section 7.6.2) include the use of free WiFi at clinics for patients waiting to obtain necessary health information. These recommendations use existing access to ICT in a new way with minimal additional cost. Additionally, the same recommendations can be applied to other diseases such as HIV, TB and hypertension.

7.5 Limitations of the study

This research is delineated specifically to the Western Cape, focusing on the City of Cape Town as this is the area with the second-highest diabetes prevalence (Kengne & Sayed, 2017)s. Despite using mixed methods to address the shortcomings in each method, the results from this exploratory research may not be generalised to the larger South African population. This is because South Africa has significant inequalities, diverse populations and cultures; therefore, it cannot be assumed that these findings may necessarily apply to the general South African population in other settings. However, the findings may provide insights for another province with similar socioeconomic demographic and geographical characteristics.

This research used mixed-methods, yet the conceptual framework built on the literature and findings from the domain of real and the domain of actual did not result in a framework that was a good predictor of use. The R^2 value only predicted 20.1% of the variability in the use of m-health apps for diabetes self-management, despite including higher-level and individual-level contextual factors. Therefore, it is probable that acceptance may be influenced by other mechanisms and structures that were not examined. For instance, in lower-income groups where medication non-adherence is common, patient engagement is crucial for an intervention's success (Nelson *et al.*, 2016). Research suggests, specifically for patients 50 years or older, that lack of additional benefits and ease of use are significant factors for the acceptance of diabetes m-health apps (Isaković *et al*., 2016). In this case, these factors should be considered in the design of future interventions.

7.6 Recommendations to apply the novel framework

Designing m-health apps rests on the assumption that a typical user has a Smartphone and access to data. However, this may not necessarily be the case for a significant portion of the Western Cape population. Therefore, other contextual factors should be considered when designing future interventions, as outlined in this section.

7.6.1 Building an m-health diabetes application prototype

Basic or feature, phones dominate device use, and access channels target those users with data and web access. Therefore, m-health for Smartphones already entails the implicit bias of increasing an already significant digital divide. Zero-rated and/or back-billed services, where the cost is absorbed by South African mobile operators, could be ways to make m-health services more accessible (Department of Health, 2015), as will the provision of applications that can be used on a basic/feature phone, such as SMS and USSD interfaces.

Recognising that an application for basic/feature phones was required, and based on the success of MomConnect, an extension of this research also involved building a prototype at a health hackathon. The prototype used the same software as MomConnect, called Vumi, which uses USSD so it can be used on Smartphones as well as feature phones (interface shown in Figure 47).

Figure 47 Sweet Life setup

Functionality includes hypo alerts (Figure 48) so that the next of kin, whose details are entered into the app, would be notified if the user fails to respond at a specified time. If this functionality is combined with a location-based service, such as 'Look for Me', then the intention is that patients in diabetic comas be found quicker and more easily.

Figure 48 **Sweet Life hypo alerts**

The prototype includes self-management activities such as blood glucose entry and motivational messages as shown in Figure 49.

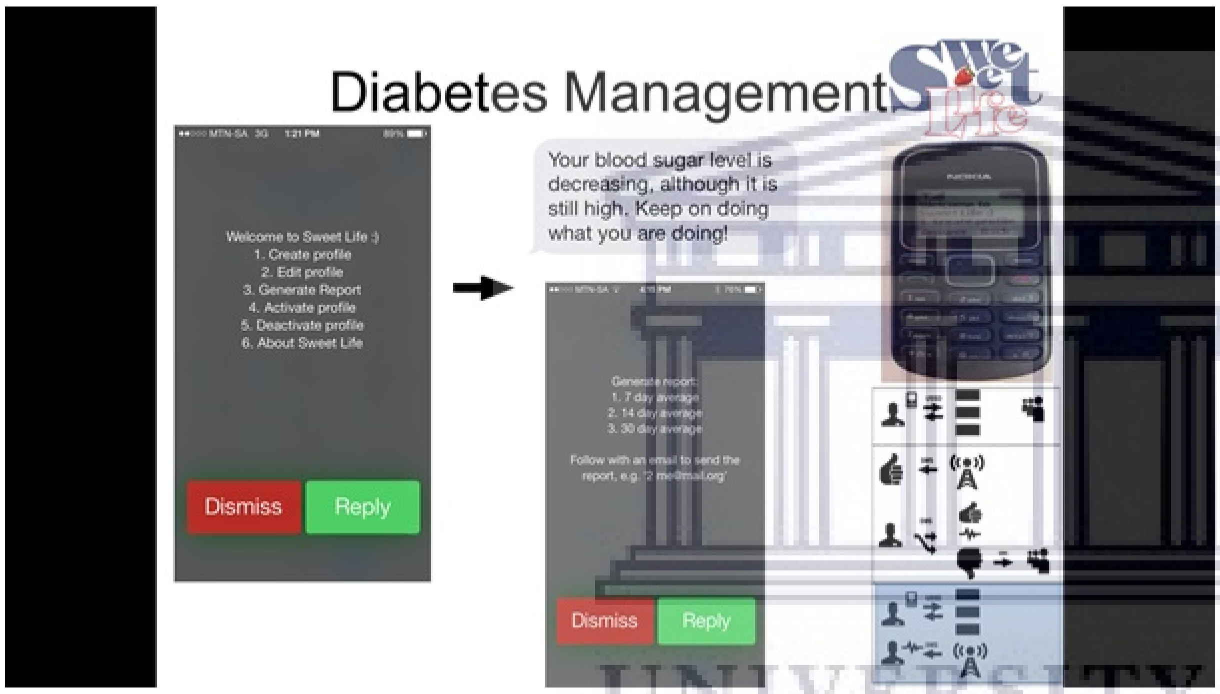


Figure 49 Sweet Life diabetes management

The hackathon allowed for the team to be part of an interview on Morning Live that showed some of the technology solutions developed to solve health challenges http://media.licdn.com/embeds/media.html?src=http%3A%2F%2Fwww.youtube.com%2Fembed%2FJjroWVwG4AY%3Ffeature%3Doembed&url=https%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3DJjroWVwG4AY&image=http%3A%2F%2Fi.ytimg.com%2Fvi%2FJjroWVwG4AY%2Fhqdefault.jpg&key=b7276e97d3f840f38fbdb95eb1242b10&type=text%2Fhtml&schema=youtube.

Despite developing the app prototype and developing a business plan, a lack of funding inhibited further progress. It is recognised that for this app or any app to work for diabetes, the NDoH and generous donor funding is required. Therefore, alternative initiatives not requiring extensive support and funding were also explored as practical avenues to achieve improved diabetes self-management. These practical and cost-effective initiatives were presented to the Western Cape Department of Health.

7.6.2 Presentation to the Western Cape Provincial Department of Health

The findings from all three domains were shared with a health assessment committee. The presentation included the following recommendations to reach more patients and, in our opinion, do not require significant amounts of time or funding to implement (refer to Figure 50).

Recommendations

- Quick and Cost effective Awareness and Use Plan
  - Give instructions on how to gain free access Wi-Fi at clinics
  - Set up a web page linking to approved health applications or health information
  - Set up tracker to count number of visits and clicks to approved information
  - Print on colourful A1 or A2 size paper and laminate. Stick up at all of the clinics especially the chronic clubs.
- Alternatively use Facebook as a method to engage and provide the information
- Set up a WhatsApp community of practice that includes a Doctor and Nurse.

Back

1. You can access free Wi-Fi at your local clinics by doing the following:
- Provide steps with pictures
2. You can access valuable resources on various health conditions
- Provide an easy to enter link to a Department website/ Facebook page with links to approved applications, resources for various conditions and illnesses (ENSURE A METHOD FOR TRACKING SITE VISITS)

Back

Figure 50 Recommendations to the Department of Health

7.7 Future work

This section presents an alternative research approach that can be pursued to make the use of m-health even more effective for people with diabetes.

Research indicates that older individuals are influenced by their perceived ability to use m-health, whereas younger individuals are influenced by their expectation of m-health performance (Faqih & Jaradat, 2015). Clearly, m-health technologies should be marketed differently for various age groups.

Additionally, m-health applications need to be designed to suit differing needs. It may be necessary, for example, to use an alternate approach such as design thinking, to design applications that may meet the needs of users more suitably, thereby enhancing use. A design thinking process consists of inspiration (problem identification that motivates the search for solutions), ideation (generation, development and testing of ideas), and implementation (instilling the solution into peoples' lives) (Johansson-Sköldberg, Woodilla & Çetinkaya, 2013).

A study by De La Harpe, Korpela and Van Zyl (2015) sought to understand m-health service use in Kenya, including the use of design thinking to design context-specific solutions. Design thinking may provide fodder for future work in this regard.

Another option for incorporating users into the design, even those with low health and ICT literacy, is to rely on user-centred design (UCD). UCD design includes research before and during the development of the intervention. Its purpose is to "understand the needs, values, and abilities of users, as well as iteratively assessing the design to improve users' perceptions of and interactions with the technology and content" (Mayberry *et al.*, 2016). The benefits of UCD are that there is a deeper understanding of users' organisational, social and ergonomic factors that affect usage as users are involved at every stage of the design and development of the product (Abras, Maloney-Krichmar & Preece, 2004). Focus groups can be included early in the design cycle to obtain requirements and issues which enrich the development of products that are more effective and safe (Abras, Maloney-Krichmar & Preece, 2004). The engagement takes into consideration the social environment and context which also leads to a securer sense of ownership and user satisfaction. The social dynamics in the target communities are important indicators of *if* and *how* ICT will be used (Ramachandran *et al.*, 2007). However, the time required and costs are high with this level of engagement (Abras, Maloney-Krichmar & Preece, 2004). Given the costs and time required to implement UCD, and the fact that m-health services are heavily dependent on donor funding (GSMA, 2013), alternatives to traditional approaches must be considered. One such alternative is positive deviance which, with the aid of ICT, holds some real potential for diabetes self-management.

Positive deviance is "the observation that in most settings a few at-risk individuals follow uncommon, beneficial practices and consequently experience better outcomes than their neighbours who share similar risks" (Marsh *et al.,* 2004:1177). This approach has been used successfully in areas of health, such as cases to improve nutritional status, newborn care, rates of contraception and safe sexual practices (Marsh *et al*., 2004). In addition, a positive deviance lens can be applied to explain why certain projects in public sector reforms, in developing countries, were successful while the majority were not. The author claims that the "Positive deviance approach has emerged as a way of identifying workable solutions to development's toughest problems. It emphasizes the importance of learning from the positive deviants within the contexts where failure is more normal; and focuses especially on learning about the strategies adopted to find and fit effective solutions" (Andrews, 2015:198).

The benefit of this approach is that it is a low-cost method of identifying beneficial strategies used by few and then encouraging the rest of the community to adopt them (Marsh *et al.*, 2004). Based on the literature reviewed, the preceding design considerations, and the notion of positive deviance, the following model (shown in Figure 51) is proposed as a foundation for a user-centred m-health intervention.

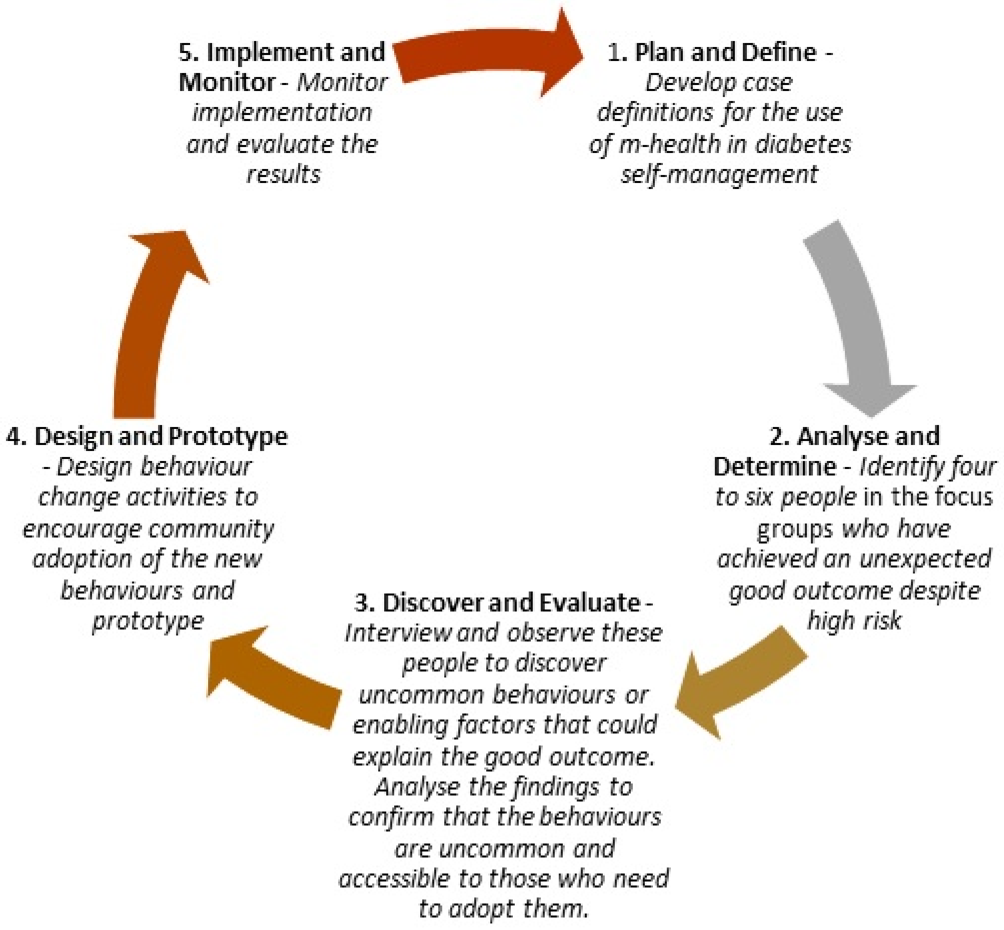


Figure 51 A way forward? Positive deviance
Modified from Marsh et al. (2004) & DSI (2014)

The use of positive deviance powered by ICT, especially m-health for diabetes self-management, is a largely untapped area. In the initial interactions with diabetes focus groups, it was not immediately apparent who demonstrated positive deviant behaviour and whether or not these behaviours could be rolled out to the community. However, further investigation may render the identification easier. If not, then the investigation into why there are not positive deviants may need to be considered and can also inform future work.

The testing of the MultiTAU model could also be undertaken within a participatory action research (PAR) paradigm. *Community-based participatory action research* (CBPR) is defined as a "systematic inquiry, with the participation of those affected by the issue being studied, for the purposes of education and taking action or effecting social change" (Leung, Yen & Minkler, 2004). This form of research uses a constructivist rather than positivist approach in which the experiential knowledge of the community is valued. The researchers work 'with' rather than 'on' communities to co-create knowledge (Leung, Yen & Minkler, 2004), rather than the researcher being regarded as the 'expert'. Thus, a CBPR approach serves to inform a mixed-methods approach to understand and solve important community problems such as health disparities (Giachello *et al.*, 2003).

It was also noted that "the most efficient way to improve health is to use locally available, sustainable, and effective approaches" (Marsh *et al.*, 2004:1177). The effects of changes introduced by improvement projects in a top-down approach are often not realised or sustainable (Baxter *et al.*, 2016). In contrast, research similar to that presented in this thesis should be using a bottom-up approach with a lens of positive deviance. In this way, CBPR should include the positive deviance approach to identify patients who currently practice good self-management and achieve good health outcomes with an eye toward that positive behaviour spreading using culturally relevant mechanisms that are defined by community members themselves. Those people would then utilise m-health solutions that they co-create to amplify positive behaviour to improve diabetes self-management for a bigger population.

Additionally, based on the qualitative findings in the domain of actual, attitude towards use could be included as a variable in MultiTAU. Self-efficacy did not influence use in this context but Zhang *et al.* (2017) found that self-efficacy is positively associated with effort expectancy. Additionally, it moderates performance expectancy towards adoption intention. As an alternative, these hypotheses can be tested.

The effect of culture on the acceptance and use of m-health apps needs to be investigated at a more granular level to understand with more clarity why respondents did not believe that their culture impacted their acceptance and use of m-health apps. This could be related to the fact that the term 'culture' may be interpreted differently by different people. Using a cultural model in a qualitative study will provide more insight into this finding that was contrary to literature (Müller, 2016; Venkatesh *et al.*, 2016; Hoque & Sorwar, 2017).

The effectiveness of m-health apps for diabetes self-management should be investigated using a model such as the IS success model (DeLone & McLean, 2003), although was considered outside the scope of this present thesis.

Despite a significant volume of literature, it is essential to note that m-health is not a silver bullet. Merely having access to a mobile phone and even data does not guarantee use and certainly not continuous use. The factors highlighted by Vaala *et al.* (2015) are still prevalent, namely:

- many patients are unaware of technologies;
- patients did not perceive their value or need them; and
- patients were not interested in using the technologies.

Nelson, Mulvaney *et al.* (2016) added to the work of Vaala *et al.* (2015) by asserting that it is difficult to promote value if the patients that are most in need of support are not engaging with an intervention. Therefore, designing and using an m-health intervention does not guarantee that it will deliver the required targets for 2020, as defined in the South Africa Strategic Plan for the Prevention and Control of Non-Communicable Diseases 2013-2017. The introduction of m-health for chronic disease management, such as with diabetes, has the potential to improve care. However, to improve the chances of success, all the links in the chain of chronic care need to be considered, not only access to a cell phone.

It was noted that the use of technology must be incorporated into a patient-centred development process to improve uptake (Vaala *et al*., 2015). This research illustrates that considering a patient's circumstance is a critical factor for success, a perspective supported by Macdonald *et al.* (2017). Researchers recommended obtaining qualitative data to understand the low engagement in high-risk groups (Nelson, Mulvaney *et al.*, 2016).

Disparities in the accessibility and availability of the internet have been reduced due to technological advances (Tennant *et al*., 2015). The lowering of barriers such as less expensive devices and mobile technologies are no longer limited to specific demographics as it is made increasingly affordable to all (Müller, 2016). Despite the burgeoning numbers of people having access to the internet as a result of more affordable phone options, though, people are not using the internet as they consider data expensive (Gillwald, Moyo & Stork, 2012).

The economic barriers identified in the domain of actual may be challenging to overcome, given the overall low level of economic growth of the country as a whole. However, government interventions to provide public access to broadband internet are present in all the communities that formed the sample for this study. This may, to a degree, mitigate problems of high internet costs in South Africa. However, this is not ideal, given that the average patient needs to use a typical m-health application daily, and therefore, less expensive access to the internet at a household level is necessary to address this barrier.

This thesis has researched the challenges for the acceptance and use of m-health apps for diabetes self-management of people with low incomes and educational attainment and from previously disadvantaged communities in the Western Cape. It has contributed to a better understanding of the challenges but concludes that more research can shed more light on the challenges. The positive deviance approach is one that has the potential to contribute. The thesis has therefore contributed, showing how diabetic patients could potentially improve the quality of their lives by making better use of what technology has to offer.

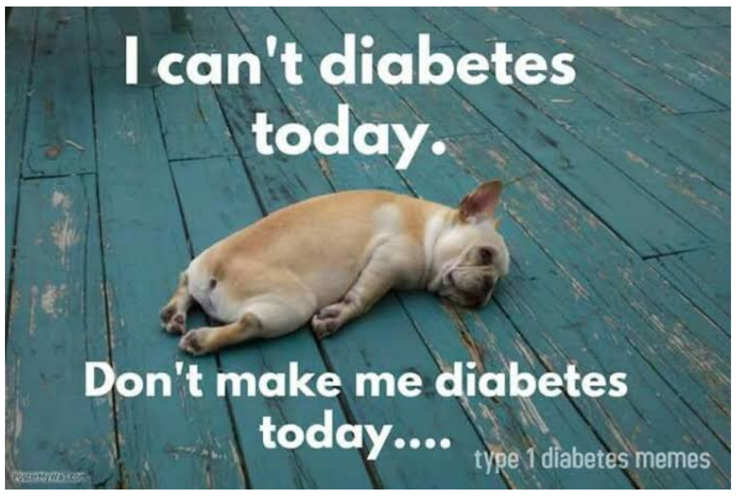
Despite the challenges identified in this section, and the limitations described above, this study has determined that there are diabetic patients who exhibit positive behavioural intention for ICT use. This bodes well for future interventions at the primary health care level, which not only promote the use of m-health for self-management of diabetes but which also incorporate education and training. The outcome of such interventions will ensure that m-health becomes integrated into diabetes patients' daily routine to self-manage the disease. In the long term, this would result in improved disease management and as such, contribute to the realisation of the SDGs concerning health amongst LMICs in particular.

8 Epilogue

I have two children, ages six and eight. I survived my first pregnancy by the skin of my teeth. I assumed that because I'm a well-controlled patient with HbA1c levels less than 6% that I shouldn't automatically be classified as a HIGH-RISK PREGNANCY... WRONG! Despite upgrading my insulin pump (so that it would automatically turn off my insulin when my blood sugar levels were dropping) and using CGM to ensure the health and safety of myself and my babies, it did not go according to plan.

*I fell over backwards when I was pregnant, knocking my head while giving a lecture and then being taken to hospital in an ambulance. Then being told that there wasn't an endocrinologist who wanted to deal with me because I was pregnant with diabetes and too HIGH RISK. Luckily, a friend was in my class who called my husband who then came to the hospital with my daughter. The **hospital had no idea how to deal with a pregnant patient with diabetes on an insulin pump**. My husband gave them instructions because they had disconnected my insulin pump while giving me a glucose drip and that meant that I was headed for a **hyperglycaemic coma**! Needless to say, I was transferred to my preferred hospital **but** I was hanging on by a thread, a very thin thread...*

I live knowing that my children are more likely to develop an autoimmune disease. Their paediatrician says that it's likely to be an autoimmune other than diabetes. So am I supposed to be less concerned by these facts☹? My son was diagnosed with low immunoglobin A levels. I'm thankful that I chose a great paediatrician who deals with high-risk babies who diagnosed this early. This means that the immune system that protects my son's surface areas, such as his skin, intestines and lungs, doesn't function as well. He was frequently ill often after birth so I did not sleep much. Exclusive breastfeeding meant that I was hypoglycaemic often too. I wasn't eligible for maternity leave either and took six weeks unpaid leave. I remember sitting marking exam scripts late at night with my baby crying on my lap. I had my first journal article accepted but I just did not have enough time to make the revisions.



Diabetes is often not very good for my SANITY. I usually use choice electives at my insulin pump during the times of constant vibrations and alerts, despite my husband reminding me that I need to take care of myself first before I can take care of our son. "You can't look after Akil when you're lying in a coma on the floor so go drink the juice first". I'll have you know that I often ignored this logic because motherhood instincts trumped my survival instincts. My motherhood instincts ***trumped everything****!*

My stories should indicate that there's A LOT more to diabetes self-management than just the functionality that can be provided by a mobile application. My excellent HbA1c is due to the technology I use, my support from my fabulous health team, my supportive family and friends. Let's not forget the ***very important*** *fact that I have* ***medical aid*** *and that I use the latest technology.* ***But*** *my PhD honestly* ***killed*** *my self-management. I've sat typing my thesis despite my pump indicating that I'm going* ***hypo*** *and all the* ***stress*** *causing me to go* ***hyper!****.*

In my opinion, I am an expert in diabetes based on 33 years of first-hand experience and four years of research, ***yet*** *I still can't get anyone in my family to manage their diabetes better. From my perspective, my research and tacit knowledge are supposed to help others by ultimately helping to answer these pertinent questions: How do we get others to manage their diabetes better? Is a mobile phone application the solution for improving diabetes self-management? Or by implementing an m-health application are we just treating every single patient with diabetes the same way when each of us is unique?*

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10 APPENDICES

10.1 Domain of real: data collection

10.1.1 Information sheet and consent form

UNIVERSITY *of the* WESTERN CAPE

Department of Economic and Management Services

INFORMATION SHEET AND CONSENT FORM FOR PARTICIPANTS IN

DIABETES QUESTIONNAIRE

Dear participant

This questionnaire and interview form part of a PhD and third-year Information Systems course (IFS 361). *The students who are approaching you are currently third-year students that are completing this as part of their group assignment to recommend a strategy to improve diabetes self-management through the use of technology for patients in the Western Cape.*

Kindly take time to read through this information sheet carefully to understand what is required from you, as a participant in this project.

As a participant, you will be required to:

Participate in an online questionnaire (taking approximately 40 minutes). The questionnaire questions are about your level of self-care activities, to manage your diabetes. As well as the use of technology, if any, to improve your self-management.

Your participation in this project is voluntary and no remuneration will be provided in return for your contribution. You remain free not to participate. Your participation in the questionnaire process might result in research which may be published, but your identity will never be revealed. ***Your responses may be used as part of a bigger research project on diabetes, conducted at UWC.*** The researcher, lecturer and principal research office will ensure your anonymity throughout the research process. If you have any questions concerning this research, feel free to contact the principal research officer:
Fazlyn Petersen: fapetersen@uwc.ac.za

I hereby consent voluntarily to participate in this project.

________________________ ________________________

Name of participant **Signature**

Date: ____________________ **Email address:** __________________________

Cell phone number: __________________________________

Thank you for your participation. Your willingness to participate in this project is appreciated.

10.1.2 Survey

Utilising Information Communication and Technology (ICT) for Diabetes Self-Management Activities

This questionnaire forms part of a PhD study and the IFS 361 Group Assignment at the University of the Western Cape (UWC). Students are completing this assignment as part of their community engagement. The project aims to improve the self-management of patients with diabetes, especially for patients from previously disadvantaged communities. This questionnaire seeks to assess the level of diabetes self-management activities. It is based on the Summary of Diabetes Self-Care Activities Measure (DJ Toobert - 2000 www.ncbi.nlm.nih.gov/pubmed/10895844) and the Unified Theory of Acceptance and Use of Technology (UTAUT) model. All information provided will be held in the strictest confidence and will not be given to any third parties. This project will respect the confidentiality of all respondents to this questionnaire and will avoid any potential harm to respondents. An information sheet and a consent form will be provided to you. You are requested to read and sign these forms before answering any questions in this survey.

This questionnaire is for patients with Type 2 diabetes living in the Western Cape and should take approximately 30 minutes to complete. A section to capture your biographical information has been included at the end to enable better analysis of the data.

Your willingness to complete this questionnaire is appreciated.

*Required

1. **Student number** *

____

2. **Group Number** *

____

Consent form for Questionnaire

3. **I agree to participate in this research. I understand that my participation in this study is voluntary and that no remuneration will be provided in return for my contribution. I am free not to participate. I am aware that the questionnaire might result in research which may be published, but that my identity will never be revealed. It is my understanding that the researcher and lecturer will ensure my anonymity throughout the research process. I retain the right of refusal to answer any question which I do not feel comfortable or able to respond to.** *

   By completing the questionnaire, respondents agree to the following : 1. That completion of this questionnaire is done voluntarily and 2. That the data collected may be analysed and the results presented at conferences and/or published in selected journals and stored in repositories at the University of the Western Cape

   Mark only one oval.

   ◯ Yes, I consent to the above

   ◯ No, I do not consent to the above

The questions below ask you about your diabetes self-care activities during the past 7 days. If you were sick during the past 7 days, please think back to the last 7 days that you were not sick.

4. DIET - How many of the last SEVEN DAYS have you followed a healthful eating plan?
Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

5. On average, over the past month, how many DAYS PER WEEK have you followed your eating plan?
Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

6. On how many of the last SEVEN DAYS did you eat five or more servings of fruits and vegetables?
Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

7. On how many of the last SEVEN DAYS did you eat high fat foods such as red meat or full-fat dairy products?
Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

8. EXERCISE - On how many of the last SEVEN DAYS did you participate in at least 30 minutes of physical activity? (Total minutes of continuous activity, including walking).
Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

9. On how many of the last SEVEN DAYS did you participate in a specific exercise session (such as swimming, walking, biking) other than what you do around the house or as part of your work?
Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

10. BLOOD SUGAR TESTING - On how many of the last SEVEN DAYS did you test your blood sugar?
Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

11. **On how many of the last SEVEN DAYS did you test your blood sugar the number of times recommended by your health care provider?**
Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

12. **FOOT CARE - On how many of the last SEVEN DAYS did you check your feet?**
Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

13. **On how many of the last SEVEN DAYS did you inspect the inside of your shoes?**
Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

14. **SMOKING - Have you smoked a cigarette—even one puff—during the past SEVEN DAYS?**
Mark only one oval.

◯ No
◯ Yes. If yes, how many cigarettes did you smoke on an average day? (Provide the number in the 'Other' field below)
◯ Other: ____________________

15. **SELF CARE RECOMMENDATIONS - Which of the following has your health care team (doctor, nurse, dietitian, or diabetes educator) advised you to do? Please check all that apply:**
Which of the following has your health care team (doctor, nurse, dietitian, or diabetes educator) advised you to do? Please check all that apply:
Tick all that apply.

☐ Follow a low-fat eating plan
☐ Follow a complex carbohydrate diet
☐ Reduce the number of calories you eat to lose weight
☐ Eat lots of food high in dietary fiber
☐ Eat lots (at least 5 servings per day) of fruits and vegetables
☐ Eat very few sweets (for example: desserts, non-diet sodas, candy bars)
☐ I have not been given any advice about my diet by my health care team.
☐ Other: ____________________

16. **Which of the following has your health care team (doctor, nurse, dietitian or diabetes educator) advised you to do? Please check all that apply:**
Tick all that apply.

- [ ] Get low level exercise (such as walking) on a daily basis.
- [ ] Exercise continuously for at least 20 minutes at least 3 times a week.
- [ ] Fit exercise into your daily routine (for example, take stairs instead of elevators, park a block away and walk, etc.)
- [ ] Engage in a specific amount, type, duration and level of exercise.
- [ ] I have not been given any advice about exercise by my health care team.
- [ ] Other: ____________________

17. **Which of the following has your health care team (doctor, nurse, dietitian, or diabetes educator) advised you to do? Please check all that apply:**
Tick all that apply.

- [ ] Test your blood sugar using a drop of blood from your finger and a colour chart.
- [ ] Test your blood sugar using a machine to read the results.
- [ ] Test your urine for sugar.
- [ ] I have not been given any advice either about testing my blood or urine sugar level by my health care team.
- [ ] Other: ____________________

18. **Which of the following medications for your diabetes has your doctor prescribed? Please check all that apply.**
Tick all that apply.

- [ ] An insulin shot 1 or 2 times a day.
- [ ] An insulin shot 3 or more times a day.
- [ ] Diabetes pills to control my blood sugar level.
- [ ] I have not been prescribed either insulin or pills for my diabetes.
- [ ] Other: ____________________

19. **DIET - On how many of the last SEVEN DAYS did you space carbohydrates evenly through the day?**
Mark only one oval.

	0	1	2	3	4	5	6	7	
days	○	○	○	○	○	○	○	○	days

20. **MEDICATIONS - On how many of the last SEVEN DAYS, did you take your recommended diabetes medication?**
Mark only one oval.

	0	1	2	3	4	5	6	7	
days	○	○	○	○	○	○	○	○	days

21. OR - On how many of the last SEVEN DAYS did you take your recommended insulin injections?

Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

22. On how many of the last SEVEN DAYS did you take your recommended number of diabetes pills?

Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

23. FOOT CARE - On how many of the last SEVEN DAYS did you wash your feet?

Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

24. On how many of the last SEVEN DAYS did you soak your feet?

Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

25. On how many of the last SEVEN DAYS did you dry between your toes after washing?

Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

26. SMOKING - At your last doctor's visit, did anyone ask about your smoking status?

Mark only one oval.

◯ No
◯ Yes

27. If you smoke, at your last doctor's visit, did anyone counsel you about stopping smoking or offer to refer you to a stop-smoking program?

Mark only one oval.

◯ No
◯ Yes
◯ Do not smoke

28. **When did you last smoke a cigarette?**
Mark only one oval.

- ◯ More than two years ago, or never smoked
- ◯ One to two years ago
- ◯ Four to eleven months ago
- ◯ One to three months ago
- ◯ Within the last month
- ◯ Today

29. **Do you think that your 'culture' plays a role in the way that you manage your diabetes?**
e.g. eating koeksisters on a Sunday morning or pap and vleis for supper?
Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ I don't know

30. **If you've answered yes to the above question - how does your culture affect the way in which your manage your diabetes?**

____
____
____
____
____

DIABETES COMPLICATIONS

31. **Have you ever had diabetes complications?**
Mark only one oval.

- ◯ Yes
- ◯ No

32. **If you have had diabetes complications before, please select the type of complication/s**
Tick all that apply.

- [ ] Skin Complications e.g. diabetic dermopathy, necrobiosis lipoidica diabeticorum, diabetic blisters and eruptive xanthomatosis
- [ ] Eye Complications e.g. glaucoma and cataracts
- [ ] Neuropathy - nerve damage from diabetes
- [ ] Foot Complications - e.g. calluses, foot ulcers, poor circulation, amputation
- [ ] DKA (Ketoacidosis) and Ketones - Diabetic ketoacidosis (DKA) is a serious condition that can lead to diabetic coma (passing out for a long time) or even death.
- [ ] Kidney Disease (Nephropathy)
- [ ] High Blood Pressure (Hypertension)
- [ ] Stroke
- [ ] Hyperosmolar Hyperglycemic Nonketotic Syndrome (HHNS) - blood sugar levels rise, and your body tries to get rid of the excess sugar by passing it into your urine
- [ ] Gastroparesis - stomach takes too long to empty its contents (delayed gastric emptying)
- [ ] Heart Disease

33. **Have you ever been admitted to hospital due to your diabetes? If yes, please complete the next question**
Mark only one oval.

- ( ) Yes
- ( ) No

34. **If you have been admitted to hospital, please provide the reason for the admission**

____
____
____
____
____

35. **When were you admitted?**
Mark only one oval.

- ( ) less than 1 year ago
- ( ) between 1 and 3 years ago
- ( ) more than 3 years ago
- ( ) I get admitted numerous times each year
- ( ) I can't remember

36. **Have you tested your Hba1C levels in the last 6 months?**
The blood test for HbA1c level is routinely performed in people with type 1 and type 2 diabetes mellitus. Blood HbA1c levels are reflective of how well diabetes is controlled.
Mark only one oval.

- ( ) Yes
- ( ) No
- ( ) I don't know

37. **If you have tested your Hba1c levels in the last 6 months, how have your HbA1C levels changed since your last test?**
Mark only one oval.

- Increased
- Decreased
- No change
- I don't know

ACCESS TO ICT

38. **How do you connect to the internet?**
Mark only one oval.

- Cell phone - Prepaid
- Cell phone - Contract
- Land line - ADSL
- Wifi
- At a public institution e.g. public library
- Internet cafe
- I don't have internet connectivity
- Other: ____________________

39. **Where do you connect to the internet most of the time?**
Mark only one oval.

- At home
- At work
- Other: ____________________

40. **If you have a glucose meter, what glucose meter do you have?**
Provide the name of your glucose meter

____
____
____
____
____

41. **If you have a glucose meter - do you download your readings?**
Mark only one oval.

- Yes
- No
- I don't know how to
- My glucose meter can't do that

42. **What do you do with your downloaded glucose readings?**
Mark only one oval.

- ◯ I analyse the results and make changes to my medication
- ◯ I show my doctor/nurse when I go for my appointment
- ◯ I don't use it because it's too complicated
- ◯ Other: ____________________

43. **Do you any other technology to help you manage your diabetes e.g. diabetes application on your smart phone, insulin pump, continuous glucose monitoring (CGM)**
Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ I don't know

44. **If you use technology, what technology do you use?**

____

____

____

____

____

45. **How often do you use the technology you have?**
Mark only one oval.

- ◯ Every day
- ◯ Weekly
- ◯ Few times a month
- ◯ Very seldom
- ◯ Never

46. **Which improvements would make you use technology more often to help improve your diabetes?**
Tick all that apply
Tick all that apply.

- ☐ Cheaper
- ☐ Easier to incorporate into daily life
- ☐ Easier to use
- ☐ Easier to understand
- ☐ More features
- ☐ Must take into account my needs and lifestyle
- ☐ I should be able to give feedback when people design the technology that is supposed to help me
- ☐ Nothing would make me use technology more
- ☐ Other: ____________________

USER ACCEPTANCE OF ICT FOR DIABETES SELF-MANAGEMENT

47. **PE_a1. I find that using Information, Communication and Technology (ICT), such as glucose machines and mobile applications, useful tools in managing my diabetes**
Mark only one oval.

	1	2	3	4	5	6	
Not at all true	◯	◯	◯	◯	◯	◯	Very true

48. **PE_a2. Using ICT enables me to accomplish tasks, such as insulin administration, carb counting and glucose testing, more quickly**
Mark only one oval.

	1	2	3	4	5	6	
Not at all true	◯	◯	◯	◯	◯	◯	Very true

49. **PE_a3. Using ICT increases my productivity as I spend less time on diabetes activities.**
Mark only one oval.

	1	2	3	4	5	6	
Not at all true	◯	◯	◯	◯	◯	◯	Very true

50. **PE_a4. Using ICT increases my chances of getting a good HBA1c reading**
Mark only one oval.

	1	2	3	4	5	6	
Not at all true	◯	◯	◯	◯	◯	◯	Very true

51. **EE _a1. My interaction with ICT is clear and understandable.**
Mark only one oval.

	1	2	3	4	5	6	
Not at all true	◯	◯	◯	◯	◯	◯	Very true

52. **EE _a2. It is easy for me to become skilful at using ICT.**
Mark only one oval.

	1	2	3	4	5	6	
Not at all true	◯	◯	◯	◯	◯	◯	Very true

53. **EE _a3. I find ICT easy to use**
Mark only one oval.

	1	2	3	4	5	6	
Not at all true	◯	◯	◯	◯	◯	◯	Very true

54. **EE _a4. Learning to operate ICT is easy for me**
Mark only one oval.

	1	2	3	4	5	6	
Not at all true	◯	◯	◯	◯	◯	◯	Very true

55. **SI_a2. People who are important to me think that I should use ICT to manage my diabetes.**
People like family, friends, doctor etc.
Mark only one oval.

	1	2	3	4	5	6	
Not at all true	◯	◯	◯	◯	◯	◯	Very true

56. **SI_a3. My health care team e.g. doctors, nurses have been helpful in the use of ICT to manage my diabetes.**
Mark only one oval.

	1	2	3	4	5	6	
Not at all true	◯	◯	◯	◯	◯	◯	Very true

57. **SI_a4. In general, my peer support group/community has supported use of ICT to manage my diabetes.**
Mark only one oval.

	1	2	3	4	5	6	
Not at all true	◯	◯	◯	◯	◯	◯	Very true

58. **FC_a1. I have the resources necessary to use ICT to manage my diabetes.**
Mark only one oval.

	1	2	3	4	5	6	
Not at all true	◯	◯	◯	◯	◯	◯	Very true

59. **FC_a2. I have the knowledge necessary to use ICT to manage my diabetes.**
Mark only one oval.

	1	2	3	4	5	6	
Not at all true	◯	◯	◯	◯	◯	◯	Very true

60. **FC_a3. Using ICT is compatible with other systems I use, such as my mobile phone.**
Mark only one oval.

	1	2	3	4	5	6	
Not at all true	◯	◯	◯	◯	◯	◯	Very true

61. **FC_a4. A specific person (or group) is available for assistance with ICT difficulties.**
Mark only one oval.

	1	2	3	4	5	6	
Not at all true	◯	◯	◯	◯	◯	◯	Very true

62. **BI_a1. I intend to use ICT to help manage my diabetes in the next month.**
Mark only one oval.

	1	2	3	4	5	6	
Not at all true	◯	◯	◯	◯	◯	◯	Very true

63. **BI_a2. I predict I would use ICT to help manage my diabetes in the next month.**
Mark only one oval.

	1	2	3	4	5	6	
Not at all true	◯	◯	◯	◯	◯	◯	Very true

64. **BI_a3. I plan to use ICT to help manage my diabetes in the next month.**
Mark only one oval.

	1	2	3	4	5	6	
Not at all true	◯	◯	◯	◯	◯	◯	Very true

BIOGRAPHICAL INFORMATION

65. Gender
Mark only one oval.

◯ Male
◯ Female

66. Age
Mark only one oval.

◯ younger than 16 years
◯ 16 - 24 years
◯ 25 - 34 years
◯ 35 - 49 years
◯ older than 50 years

67. **Race**
Mark only one oval.

- ◯ Black
- ◯ Coloured
- ◯ Indian
- ◯ White
- ◯ Other: ______________

68. **Type of diabetes**
Mark only one oval.

- ◯ Type 1 - juvenile onset (diagnosed when young), insulin dependent
- ◯ Type 2 - insulin resistant, using oral diabetes medication e.g. metformin, glucophage
- ◯ Type 2 - using oral diabetes medication and insulin
- ◯ Gestational diabetes - diabetes during pregnancy
- ◯ Latent autoimmune diabetes of adults (LADA) - Type 1 insulin dependent diabetes (diagnosed in adults, when older)
- ◯ Prediabetic

69. **How long have you had diabetes?**
Mark only one oval.

- ◯ less than 1 year
- ◯ 1 - 3 years
- ◯ 4 - 6 years
- ◯ 6 - 9 years
- ◯ 10 - 15 years
- ◯ more than 15 years

70. Province

Area where you reside/live

Mark only one oval.

- ◯ Eastern Cape
- ◯ Free State
- ◯ Gauteng
- ◯ KZN
- ◯ Limpopo
- ◯ Northern Cape
- ◯ North West
- ◯ Mpumalanga
- ◯ Western Cape
- ◯ Australia
- ◯ Canada
- ◯ Europe
- ◯ UK
- ◯ USA
- ◯ South America
- ◯ Other: ____________________

71. **Area where you reside/live on the Cape Flats**
If you choose Other then please specify where
Mark only one oval.

- Athlone
- Belhar
- Bokaap
- Bonteheuwel
- Crossroads
- Delft
- Eagle Park
- Elsies River
- Grassy Park
- Gugulethu
- Heideveld
- Hanover Park
- Lansdowne, Cape Town
- Khayelitsha
- Lavender Hill
- Lotus River
- Nyanga
- Manenberg
- Mfuleni
- Mitchell's Plain
- Ottery,Cape Town
- Parkwood
- Pelican Park
- Retreat
- Strandfontein
- Other: ____________

72. **Home language**
Mark only one oval.

- English
- Afrikaans
- Xhosa
- Zulu
- Other: ____________

73. **Marital status**
Mark only one oval.

- Single
- Married
- Divorced
- Widowed

74. **Income**
per month
Mark only one oval.

- Less than R500
- R500 - R899
- R900 - R1399
- R1400 - R2499
- R2500 - R3999
- R4000 - R6999
- R7000 - R11999
- R12000 or more

75. **Highest educational level**
Mark only one oval.

- No schooling
- Primary school
- Some primary schooling
- Some high schooling
- Matric (Grade 12) - Senior Certificate
- Technikon
- Diploma or Certificate
- University Degree
- Other: ____________

76. **Are you currently on medical aid?**
Mark only one oval.

- Yes
- No

10.2 Domain of actual: data collection

10.2.1 Information sheet and consent form

UNIVERSITY *of the* WESTERN CAPE

Department of Economic and Management Services

INFORMATION SHEET AND CONSENT FORM FOR PARTICIPANTS IN DIABETES INTERVIEW

Dear participant

This questionnaire and interview form part of a PhD and third-year Information Systems course (IFS 361). *The students who are approaching you are currently third-year students that are completing this as part of their group assignment to recommend a strategy to improve diabetes self-management through the use of technology for patients in the Western Cape.*

Kindly take time to read through this information sheet carefully to understand what is required from you, as a participant in this project.

As a participant, you will be required to:

1. ***Participate in an interview. The interview questions are about your level of self-care activities, to manage your diabetes. As well as the use of any technology, if any, to improve your self-management.***
2. ***Your interview will be recorded. This is to verify the validity of the interview and allow the students to transcribe it.***

Your participation in this project is voluntary and no remuneration will be provided in return for your contribution. You remain free not to participate. Your participation in the interview process might result in research which may be published, but your identity will never be revealed. ***Your responses may be used as part of a bigger research project on diabetes, conducted at UWC.*** The researcher, lecturer and principal research office will ensure your anonymity throughout the research process. If you have any questions concerning this research, feel free to contact the principal research officer:
Fazlyn Petersen: fapetersen@uwc.ac.za

I hereby consent voluntarily to participate in this project.

__________________________ __________________________

Name of participant **Signature**

Date: ____________________ **Email address:** __________________________

Cell phone number: ____________________________________

Thank you for your participation. Your willingness to participate in this project is appreciated.

10.2.2 Interview guide

1. **Which technology (ICT) do you use to help manage your diabetes?**
Prompt if required: Do you use a glucose testing machine? Do you search for diabetes-related information on the internet? Do you use an application on your mobile phone?
2. **What prevents you from using ICT for managing your diabetes?**
Prompt if required: If they don't use ICT, ask them if it's related to cost or whether it's too difficult to use. Is it anything else?
3. **Who gives you support for managing your diabetes?**
Prompt if required: Their family, spouses, children? Do they get online support, like diabetes Facebook or WhatsApp groups?
4. **Do you think that your skills or education impact your ability to use ICT for your diabetes? Why?**
5. **How do you connect to the internet?**
Prompt if required: If they say that they don't use the internet, then ask them why they don't use it. Some respondents won't know that they are using the internet, so ask them whether they use Facebook or WhatsApp.
6. **How do you feel about using ICT to manage your diabetes?**
Prompt if required: Is using ICT to manage your diabetes somewhat intimidating? Do you fear to make mistakes?
7. **Do you find ICT useful for managing your diabetes?**
Prompt if required: Does it help you achieve better results when you go to the doctor?
8. **What would make you better at managing their diabetes?**
Prompt if required: Would or could technology make it better or easier? If so, how?
9. **What do you like or dislike about the current technology for managing your diabetes?**
Prompt if required: Is it easy to use and understand? Is it easy to incorporate into your life?
10. **Which improvements would make you use technology more often to help improve your diabetes?**

10.3 Domain of empirical: data collection

10.3.1 Information sheet and consent form

UNIVERSITY *of the* WESTERN CAPE

Department of Economic and Management Services

INFORMATION SHEET AND CONSENT FORM FOR PARTICIPANTS IN DIABETES QUESTIONNAIRE

Dear participant

This questionnaire and interview form part of a PhD and third-year Information Systems course (IFS 361). *The students who are approaching you are currently third-year students that are completing this as part of their group assignment to recommend a strategy to improve diabetes self-management through the use of technology for patients in the Western Cape.*

Kindly take time to read through this information sheet carefully to understand what is required from you, as a participant in this project.

As a participant, you will be required to:

Participate in an online questionnaire (taking approximately 40 minutes). The questionnaire questions are about your level of self-care activities, to manage your diabetes. As well as the use of mobile health used, if any, to improve your self-management.

Your participation in this project is voluntary and no remuneration will be provided in return for your contribution. You remain free not to participate. Your participation in the questionnaire process might result in research which may be published, but your identity will never be revealed. ***Your responses may be used as part of a bigger research project on diabetes, conducted at UWC.*** The researcher, lecturer and principal research office will ensure your anonymity throughout the research process. If you have any questions concerning this research, feel free to contact the principal research officer:
Fazlyn Petersen: fapetersen@uwc.ac.za

I hereby consent voluntarily to participate in this project.

_________________________ _________________________

Name of participant **Signature**

Date: ____________________ **Email address:** _________________________

Cell phone number: ______________________________

Thank you for your participation. Your willingness to participate in this project is appreciated.

10.3.2 Survey

Using mobile health (m-health) applications for diabetes self-management activities

This questionnaire forms part of a PhD study and the IFS 361 Group Assignment at the University of the Western Cape (UWC). Students are completing this assignment as part of their community engagement. The project aims to improve the self-management of patients with diabetes, especially for patients from previously disadvantaged communities. This questionnaire seeks to assess the level of diabetes self-management activities. It is based on the Summary of Diabetes Self-Care Activities Measure (DJ Toobert - 2000 www.ncbi.nlm.nih.gov/pubmed/10895844) and the Multi-level Framework of Technology Acceptance and Use model. All information provided will be held in the strictest confidence and will not be given to any third parties. This project will respect the confidentiality of all respondents to this questionnaire and will avoid any potential harm to respondents. An information sheet and a consent form will be provided to you. You are requested to read and sign these forms before answering any questions in this survey.

This questionnaire is for patients with Type 2 diabetes living in the Western Cape and should take approximately 30 minutes to complete. A section to capture your biographical information has been included at the end to enable better analysis of the data.

Your willingness to complete this questionnaire is appreciated.

* Required

1. **Student number** *

2. **Group Number** *
   Please ensure that this is EXACTLY the same as the Group number on ikamva as it will be used to sort and assign group marks for the completion of Task 1

Consent form for Questionnaire

PLEASE ENSURE THAT YOU PROVIDE THE PERSON ANSWERING WITH QUESTIONNAIRE WITH THE INFORMATION SHEET AND CONSENT FORM.PDF. ENSURE THAT THEY PHYSICALLY SIGN THE FORMS AS WELL.

3.
I agree to participate in this research. I understand that my participation in this study is voluntary and that no remuneration will be provided in return for my contribution. I am free not to participate. I am aware that the questionnaire might result in research which may be published, but that my identity will never be revealed. It is my understanding that the researcher and lecturer will ensure my anonymity throughout the research process. I retain the right of refusal to answer any question which I do not feel comfortable or able to respond to. *

By completing the questionnaire, respondents agree to the following : 1. That completion of this questionnaire is done voluntarily and 2. That the data collected may be analysed and the results presented at conferences and/or published in selected journals and stored in repositories at the University of the Western Cape

Mark only one oval.

- Yes, I consent to the above
- No, I do not consent to the above

ACCESS TO ICT

This section is to access the availability of items such as internet so that people can use m-health

4.
I have access to the internet that enables me to use mobile health (m-health) applications to help manage my diabetes.

Some people won't know that they're using the internet, so ask them if they're using items like Facebook and WhatsApp

Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

5.
I know how to search for and find mobile applications that will help me manage my diabetes better.

Find out if they know how to use Google Play or the Apple App Store

Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

6.

How do you connect to the internet?

Some people may not know that they're connecting to the internet so ask them if they buy data or WhatsApp bundles

Mark only one oval.

- ◯ Cell phone - Prepaid
- ◯ Cell phone - Contract
- ◯ Land line - ADSL
- ◯ WiFi
- ◯ At a public institution e.g. public library
- ◯ Internet cafe
- ◯ I don't have internet connectivity

7.

Where do you connect to the internet most of the time?

Mark only one oval.

- ◯ At home
- ◯ At work
- ◯ Other: ____________________

8.

Which improvements would make you use technology more often to help improve your diabetes?

Mark only one oval.

- ◯ Cheaper
- ◯ Easier to incorporate into daily life
- ◯ Easier to use
- ◯ Easier to understand
- ◯ More features
- ◯ Must take into account my needs and lifestyle
- ◯ I should be able to give feedback when people design the technology that is supposed to help me
- ◯ Nothing would make me use technology more

SUMMARY OF DIABETES CARE ACTIVITIES

The questions below ask you about your diabetes self-care activities during the past 7 days. If you were sick during the past 7 days, please think back to the last 7 days that you were not sick.

9.
MEDICATION - On how many of the last SEVEN DAYS, did you use a mobile application to help you take your recommended diabetes medication?
Did they use reminders on their mobile application or smart phones to take their injections or oral medication?
Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

10.
DIET - How many of the last SEVEN DAYS have you used a mobile health application to help you follow a healthful eating plan?
Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

11.
On average, over the past month, how many DAYS PER WEEK have you used a mobile health application to help you follow your eating plan?
Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

12.
On how many of the last SEVEN DAYS did you use a mobile application to assist you to eat five or more servings of fruits and vegetables?
Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

13.
On how many of the last SEVEN DAYS did you use a mobile application to assist you not to eat high fat foods such as red meat or full-fat dairy products?
Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

14.

EXERCISE - On how many of the last SEVEN DAYS did you use a mobile application to assist you to participate in at least 30 minutes of physical activity? (Total minutes of continuous activity, including walking).

Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

15.

EXERCISE - On how many of the last SEVEN DAYS did you use a mobile application to record your participation in at least 30 minutes of physical activity? (Total minutes of continuous activity, including walking).

Did they use an activity tracker? Items like pedometers or Google fit?

Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

16.

On how many of the last SEVEN DAYS did you use a mobile application to remind you to participate in a specific exercise session (such as swimming, walking, biking) other than what you do around the house or as part of your work?

Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

17.

BLOOD SUGAR TESTING - On how many of the last SEVEN DAYS did you use a mobile application to assist you with your blood sugar testing?

Did you use your mobile application to remind you to test and record your blood sugar levels?

Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

18.

On how many of the last SEVEN DAYS did you use a mobile application to assist you with your blood sugar the number of times recommended by your health care provider?

Did you use your mobile application to remind you to test and record your blood sugar levels the number of times that you were supposed to?

Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

19.

FOOT CARE - On how many of the last SEVEN DAYS did you use you a mobile application to assist you with foot care?

Did you use your mobile application to remind you to check your feet (and complete activities like washing, soaking and drying them) and record your results?

Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

20.

On how many of the last SEVEN DAYS did you use a mobile application to remind you to check the inside of your shoes?

Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

21.

SMOKING - Have you smoked a cigarette—even one puff—during the past SEVEN DAYS?

Mark only one oval.

◯ Yes

◯ No

22.

On how many of the last SEVEN DAYS did you use a mobile application to assist you in managing your smoking?

Do you have a smoking management plan on your mobile application?

Mark only one oval.

	0	1	2	3	4	5	6	7	
days	◯	◯	◯	◯	◯	◯	◯	◯	days

23.
SELF CARE RECOMMENDATIONS - Which of the following has your health care team (doctor, nurse, dietitian, or diabetes educator) advised you to do? Please check all that apply:
Which of the following has your health care team (doctor, nurse, dietitian, or diabetes educator) advised you to do? Please check all that apply:
Check all that apply.

- [ ] Follow a low-fat eating plan
- [ ] Follow a complex carbohydrate diet
- [ ] Reduce the number of calories you eat to lose weight
- [ ] Eat lots of food high in dietary fiber
- [ ] Eat lots (at least 5 servings per day) of fruits and vegetables
- [ ] Eat very few sweets (for example: desserts, non-diet sodas, candy bars)
- [ ] I have not been given any advice about my diet by my health care team.

USER ACCEPTANCE OF MOBILE HEALTH FOR DIABETES SELF-MANAGEMENT

This is based on the UTAUT model by Venkatesh

24.
PE_a1. I find that using mobile applications, useful tools in managing my diabetes.
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	Strongly agree

25.
PE_a2. Using mobile application enables me to accomplish tasks, such as insulin administration, carb counting and glucose testing, more quickly.
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	Strongly agree

26.
PE_a3. Using mobile applications increases my productivity as I spend less time on diabetes activities.
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	Strongly agree

27.
PE_a4. Using mobile applications increases my chances of getting a good HBA1c reading.
The blood test for HbA1c level is routinely performed in people with type 1 and type 2 diabetes mellitus. Blood HbA1c levels are reflective of how well diabetes is controlled.
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	Strongly agree

28.
EE _a1. My interaction with mobile applications to manage my diabetes is clear and understandable.
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	Strongly agree

29.
EE _a2. It is easy for me to become skilful at using mobile applications for managing my diabetes.
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	Strongly agree

30.
EE _a3. I find mobile applications for managing my diabetes easy to use.
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	Strongly agree

31.
EE _a4. Learning to operate mobile applications for managing my diabetes is easy for me.
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	Strongly agree

32.

AT_a1. Using mobile applications to manage my diabetes is a good idea.

Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree									Strongly agree

33.

AT_a2. Using mobile applications makes managing my diabetes more effective than traditional methods like visiting the doctor.

Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree									Strongly agree

34.

AT_a3. Managing my diabetes with mobile applications is more fun than traditional methods, like visiting the doctor.

Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree									Strongly agree

35.

AT_a4. I like using mobile application to manage my diabetes.

Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree									Strongly agree

36.

SI_a1. People who influence my behaviour think that I should use mobile applications to manage my diabetes.

People like family, friends, doctor etc.

Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree									Strongly agree

37.

SI_a2. People who are important to me think that I should use mobile applications to manage my diabetes.

People like family, friends, doctor etc.

Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

38.

SI_a3. My health care team e.g. doctors, nurses have been helpful in the use of mobile applications to manage my diabetes.

Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

39.

SI_a4. In general, my peer support group/community has supported use of mobile applications to manage my diabetes.

Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

40.

FC_a1. I have the resources (e.g. a smart phone and access to the internet) necessary to use mobile applications to manage my diabetes.

Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

41.

FC_a2. I have the knowledge necessary to use mobile applications to manage my diabetes.

Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

42.
FC_a3. Using mobile applications to manage my diabetes is compatible with other systems I use, such as my glucose testing machine.
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	Strongly agree

43.
FC_a4. A specific person (or group) is available for assistance with difficulties when using my mobile application used for my diabetes.
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	Strongly agree

44.
FC_a5. Mobile applications are affordable and use a little data.
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	Strongly agree

45.
SE_a1. I can complete a self-care activity, such as managing my diet, using mobile applications, if there is no one around to tell me what to do as I go.
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	Strongly agree

46.
SE_a2. I can complete a self-care activity, such as managing my diet, using mobile applications if I can call someone for help if I get stuck.
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	Strongly agree

47.

SE_a3. I can complete a self-care activity using mobile applications, if I have a lot of time to complete the job for which the mobile applicatioin is provided.

Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

48.

SE_a4. I can complete a self-care activity using mobile application, if I have just the built-in help facility for assistance.

Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

49.

AX_a1. I feel apprehensive about using mobile applications to manage my diabetes.

Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

50.

AX_a2. It scares me to think that someone else could obtain my personal and sensitive information using by mobile application to manage my diabetes.

Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

51.

AX_a3. It scares me to think that I can enter the incorrect information.

Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

52.
AX_a5. Using mobile applications to manage my diabetes is somewhat intimidating to me.
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

53.
HB_a1. I make it a habit to use mobile applications to help manage my diabetes.
Noone forces me to use mobile applications
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

54.
HB_a2. I like using mobile applications to help manage my diabetes on a daily basis.
Noone forces me to use mobile applications
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

55.
HB_a3. I use mobile applications to help manage my diabetes without thinking.
Noone forces me to use mobile applications
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

56.
HB_a4. I am addicted to ung mobile applications to help manage my diabetes.
Noone forces me to use mobile applications
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

57.
BI_a1. I intend to use mobile applications to help manage my diabetes in the next month.
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

58.
BI_a2. I predict I would use mobile applications to help manage my diabetes in the next month.
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

59.
BI_a3. I plan to use mobile applications to help manage my diabetes in the next month.
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

60.
Exp1: For how long have you been using a smart phone?
Mark only one oval.

- ⬭ I've never used a smart phone
- ⬭ less than a year
- ⬭ 1 - 3 years
- ⬭ 4 - 6 years
- ⬭ 7 - 10 years
- ⬭ 11 - 15 years
- ⬭ 15 - 20 years
- ⬭ more than 20 years

61.
Exp2: Approximately how many hours per week do you use your smart phone?
Mark only one oval.

- ◯ I've never used a smart phone
- ◯ less than 1 hour
- ◯ 1 - 3 hours
- ◯ 4 - 6 hours
- ◯ 7 - 10 hours
- ◯ 11 - 15 hours
- ◯ 15 - 20 hours
- ◯ more than 20 hours

62.
Exp3: For how long have you been using the internet?
How long have they been using items like Facebook and WhatsApp?
Mark only one oval.

- ◯ I've never used a smart phone
- ◯ less than a year
- ◯ 1 - 3 years
- ◯ 4 - 6 years
- ◯ 7 - 10 years
- ◯ 11 - 15 years
- ◯ 15 - 20 years
- ◯ more than 20 years

63.
Cul_a1. My culture affects my ability to adopt mobile applications to help manage my diabetes.
E.g. women don't have access to smart phones
Mark only one oval.

	0	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	Strongly agree

64.
How does your culture affect your ability to adopt mobile applications to help manage your diabetes?

____
____
____
____
____

Biographical information

65.
Gender
Mark only one oval.

- ◯ Male
- ◯ Female

66.
Age
Mark only one oval.

- ◯ younger than 16 years
- ◯ 16 - 24 years
- ◯ 25 - 34 years
- ◯ 35 - 49 years
- ◯ older than 50 years

67.
Race
Mark only one oval.

- ◯ Black
- ◯ Coloured
- ◯ Indian
- ◯ Indian
- ◯ Other: ______________________________

68.
Type of diabetes
Mark only one oval.

- ◯ Type 1 - juvenile onset (diagnosed when young), insulin dependent
- ◯ Type 2 - insulin resistant, using oral diabetes medication e.g. metformin, glucophage
- ◯ Type 2 - using oral diabetes medication and insulin
- ◯ Gestational diabetes - diabetes during pregnancy
- ◯ Latent autoimmune diabetes of adults (LADA) - Type 1 insulin dependent diabetes (diagnosed in adults, when older)
- ◯ Prediabetic

69.
How long have you had diabetes?
Mark only one oval.

- ◯ less than 1 year
- ◯ 1 - 3 years
- ◯ 4 - 6 years
- ◯ 6 - 9 years
- ◯ 10 - 15 years
- ◯ more than 15 years

70.
Province
Area where you reside/live
Mark only one oval.

- ◯ Eastern Cape
- ◯ Free State
- ◯ Gauteng
- ◯ KZN
- ◯ Limpopo
- ◯ Northern Cape
- ◯ North West
- ◯ Mpumalanga
- ◯ Western Cape

71.

Area where you reside/live in the Western Cape

If you choose Other then please specify where

Mark only one oval.

- Athlone
- Belhar
- Bokaap
- Bonteheuwel
- Crossroads
- Delft
- Eagle Park
- Elsies River
- Grassy Park
- Gugulethu
- Heideveld
- Hanover Park
- Lansdowne
- Khayelitsha
- Lavender Hill
- Lotus River
- Nyanga
- Manenberg
- Mfuleni
- Mitchell's Plain
- Ottery
- Parkwood
- Pelican Park
- Retreat
- Strandfontein
- Other: ____________

72.
Home language
Mark only one oval.

- English
- Afrikaans
- Xhosa
- Zulu
- Other: ____________________

73.
Marital status
Mark only one oval.

- Single
- Married
- Divorced
- Widowed
- Other: ____________________

74.
Income
per month
Mark only one oval.

- Less than R500
- R500 - R899
- R900 - R1399
- R1400 - R2499
- R2500 - R3999
- R4000 - R6999
- R7000 - R11999
- R12000 or more

75.

Highest educational level

Mark only one oval.

- ◯ No schooling
- ◯ Some primary schooling
- ◯ Primary school
- ◯ Some high schooling
- ◯ Matric (Grade 12) - Senior Certificate
- ◯ Technikon
- ◯ Diploma or Certificate
- ◯ University Degree

76.

Are you currently on medical aid?

Mark only one oval.

- ◯ Yes
- ◯ No

10.3.3 Certificate of authentication

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ChickPea

Certificate of Authenticity

CERTIFICATE: **COA161119(FP)**

09 December 2019

To Whom It May Concern

This is to certify that "**Determinants for the acceptance and use of mobile health applications: Diabetic patients in the Western Cape, South Africa**" by Fazlyn Petersen, for the University of the Western Cape, has been professionally edited by Dr. Laura Budler Kleinhans of ChickPea Proofreading and Editing Services for Students and Professionals.

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