# Mobile Technology Adoption for Improved Maternal Healthcare in Sudan

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## Plagiarism Declaration

### Declaration

Hereby I, Duha Zakaria, declare that **"*Mobile technology adoption for improved maternal healthcare in Sudan"*** is my own 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 in order to obtain an academic qualification.

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**Abstract**

Mobile health applications are becoming increasingly prominent worldwide as it is known for delivering effective interventions in healthcare. Moreover, mobile health technologies are vital in achieving SDG 3 (Good Health and Well-being) by 2030, with targets 3.1 and 3.2 having specific relevance to this study. Target 3.1 seeks to "*reduce the global maternal mortality ratio to less than 70 per 100,000 live births*". Target 3.2 seeks to "*end preventable deaths of new-borns and children under five years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births*". In the field of maternal health, mobile health (m-health) interventions have demonstrated success in enhancing the access and delivery of maternal services. The potential of mobile health (m-health) technologies to transform healthcare delivery in developing countries such as Sudan has been established. Previous studies indicate that many factors influence technology adoption such as behavioural, socio-cultural and demographic factors. Therefore, further investigation of the adoption of mobile health applications among pregnant women in the Sudanese context is important as there is a lack of information for that region which in turn limits and impedes the adoption of m-health applications.

Therefore, this study, used the Unified-theory of Acceptance and Use of Technology (UTAUT) model as a lens to identify the factors influencing the adoption of m-health applications, among pregnant women in a typical developing country. Sudan served as the setting for the empirical investigation to answer the research question "*What factors affect pregnant women's perceptions of adopting maternal health-related mobile applications?*".

**Research design and methodology:** This study used a qualitative methodology and applied a case study design. The researcher conducted one-on-one interviews with pregnant women as the targeted population for this study. Using content analysis, an inductive approach was taken to code text into categories that were aligned to the UTAUT constructs.

**Findings:** The qualitative analysis resulted in five themes derived from several coding categories and underlying concepts which explain factors that influence the adoption of m-health applications by pregnant women in Sudan. . The key findings revealed that privacy concerns negatively influence pregnant women's perceptions of using m-health applications. It was found that participants had low trust in technology and were also concerned about their data privacy. Besides the lack of smartphones and stable electricity, language barriers were

challenges to adoption. Significantly, the socio-cultural factors negatively influence pregnant women's perceptions as they have less access to technology and maternity practices strongly following cultural beliefs.

**Future work:** Further research is recommended to investigate the development processes of m-health applications and interventions for maternal healthcare in Sudan. Future work should be based on a co-design models in which pregnant women and healthcare providers are involved to facilitate the adoption of the m-health tools for pregnant women, which in turn would increase acceptability and trust.

**Keywords:**

Technology adoption, technology acceptance, e-health, m-health, pregnant women, maternal healthcare, technology usage, UTAUT, developing countries, Khartoum, Sudan

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## Dedications

This thesis is dedicated to my father's soul, may Allah Almighty bless his soul. To my mother I am grateful for her endless love, encouragement and support as she has never stopped believing in me and always kept me in her Duas.

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**Acronyms used in this study**

| | |
|---|---|
| UTAUT | Unified-Theory of Acceptance and Use of Technology |
| SCT | Social cognitive theory |
| DOI | Diffusion of innovation theory |
| M-HEALTH | Mobile health |
| TAM | Technology acceptance model |
| E-HEALTH | Electronic health |
| WHO | World health organisation |
| SDG | Sustainable development goals |
| ICT | Information and communication technology |

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# Chapter 1: Introduction and background to the study

## 1.1 Context of the research problem

Promoting health and well-being is one of the goals of sustainable development, as healthy people can contribute better to the country's development (World Health Organization, 2020). Globally, progress has been made toward increasing coverage of primary healthcare for all ages. The Sustainable Development Goals (SDGs), which is a call for action by all countries, have been developed to achieve the United Nations' "integrated and divisible" objectives across environment, economic and social dimensions (United Nations, 2015). Similarly, (WHO, 2021) indicates that the sustainable development agenda for 2030 reflects the linkage between health and development and how achieving improved healthcare would widen the economy, social inequalities, and urbanisation. Moreover, these agendas consist of 17 SDGs, while goal 3 focuses on good health and well-being of people of all ages. Hasan et al. (2020) indicate that sustainable development requires strengthening health systems to ensure universal health care coverage and promote global health and well-being. Therefore, the 2030 agenda objectives integrated the scope of health equity for fairness of health distributions in the communities to achieve universal healthcare coverage and guarantee health care services accessible for all (Christophersen, 2018).

The 2030 agenda includes many aspects of health care, including maternal health. Reducing maternal mortality and morbidity is crucial in improving healthcare outcomes and strengthening the quality of care (Konduri et al., 2018). Furthermore, investing in maternal health is important as women are essential economic drivers and are critical to long-term sustainable economic development. Investing in maternal health improves the overall health system that benefits the entire population (Schatz, Seeley & Zalwango, 2018).

The progress in improving maternal health proposed a much broader agenda that catalyses the efforts in maternal survival and access to family planning and contraception (Weiss et al., 2022). Mehra et al. (2020) note that improving reproductive health has emphasised reducing maternal mortality, a barrier to achieving sustainability. It is important to realise that delivering healthcare services depends on digital solutions in the era of technology. Thus, health interventions that rely on Information Systems (IS) and associated IT artefacts can improve access, utilisation, and quality of maternal health services (Chi & Urdal, 2018). Also, such interventions provide a comprehensive approach to addressing the health needs of women, especially those located in rural communities (Shariff & Sharma, 2018).

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Moreover, digitalised interventions resulting from technology investments have been made in maternal health, as technology has shown more rapid progress in enhancing healthcare services (Kusyanti et al., 2022). The application of technology in healthcare has led to the development of health Information Systems (IS) that respond to maternal and neonatal needs and improve services access and utilisation (Nehme et al., 2021). Furthermore, evidence shows that ICT type interventions have positively impacted women's health by empowering them to make informed decisions regarding their health (Sendlhofer et al., 2018). In addition, information systems have provided solutions to various maternal health barriers in low and middle-income countries (Akeju et al., 2022). However, strengthening healthcare requires a functional healthcare system built around the six building blocks of the health framework: service delivery, health workforce, health information systems, leadership/governance, finance, and access to essential medicines (Durocher et al., 2021).

Together with the other components of the health framework, health information systems include mobile phone applications in healthcare. Mobile health (m-health) is defined as "medical and public health practice supported by mobile devices such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wearable devices" (World Health Organization, 2011:6). Mobile health (m-health) applications are deemed as a self-management tool as it can record patient information and remind them to administer medication (Karim et al., 2020). Research indicates that m-health has become increasingly prominent worldwide to strengthen healthcare systems, such as reducing maternal morbidity and improving new-born survival (Chen et al., 2020). Furthermore, in maternal health, mobile health (m-health) innovations have introduced more solutions to improve the diagnosis, clinical monitoring, and management of pregnancy health outside of traditional care settings (Taboada et al., 2021). In addition, Signorini et al. (2018) found that technological innovations such as remote telemonitoring services in maternal health assist in preventing unfavourable pregnancy outcomes. Notably, the utilisation of technology has proved its support in point-of-care services, health promotion, and health behaviour change in maternal health. (Akeju et al., 2022).

Adopting information and communication technology to tackle health problems are linked to the patient's behaviour toward accepting the technology. As a newly emerging innovation, mobile health services have encountered numerous challenges (Ojo, 2018). Rodriguez-Patarroyo et al. (2021) illustrate that technology acceptance barriers are mobile network

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availability and stability in rural areas. Alongside users' existing behavioural constraints towards technology interventions, that is a significant obstacle facing innovative solutions.

Webber, Chirangi and Magatti (2020) examined pregnant women's perspectives towards using mobile phones in maternal services. The findings indicate that women expressed a generally positive perception regardless of mobile health services and that they understood the effectiveness of using technology. However, most women raised concerns about utilising mobile phones to obtain counselling and health information.

In Africa, one example of a maternal health mobile application is Mom-connect, introduced in 2014 by the National Department of Health in South Africa as a digital health intervention. The mom-Connect technical solution was implemented to strengthen the quality of maternal and infant health services and improve mortality outcomes. This mobile application is also used to register pregnancies in public health systems and interact with registered women (Barron et al., 2018).

Peter et al. (2018) point out that m-health application registers are more than 60% of pregnant women attend their first antenatal appointment. Yet, registration levels should increase and be part of the standard protocol for every pregnant woman's first visit to achieve adequate system performance. However, there are low levels of its use. M-health application and use for maternal health are still limited due to the factors influencing registration, population levels coverage, and exposure to health information content (Mehl et al., 2018).

Gu et al. (2021) indicate that low levels of technology adoption are related to several factors, including socio-economic, geographic, and cultural factors. For instance, formal education is considered a factor that affects pregnant women's adoption and utilisation of technology. In using a text-messaging program, the recipient requires an adequate literacy level. Another factor is gender inequalities that prevent some pregnant women from accessing primary healthcare, as gender issues can be obstacles to mobile health utilisation (Sadoughi Ali & Erfannia, 2020). For example, Khan et al. (2019) found that besides privacy concerns, pregnant women revealed that their husbands would not allow them to own or use a mobile phone to make calls. According to Addotey-Delove et al (2020), women require permission from their parents, husbands or partners in order to use a cellphone, citing a 'gatekeeper effect'. It was also noted that husbands expressed concerns about the confidentiality of their wife's health information shared on a network as a kind of ethical concern.

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To provide insight into the population of the research problem, the next section discusses the research context in Sudan which served as the site of study.

## 1.2    Overview of the digital environment of Sudan

Sudan is the largest and one of the most diverse countries in the African continent, known as the home of the desert, mountains, and rainforests. The country plays a significant role in Africa's diffusion of civilisation, culture, and knowledge. Also, the society in Sudan is multi-racial, consisting of ethnic minorities and different cultures. In 1991 the Information and Communication Technology (ICT) strategy was set with high-level committee supervision to oversee its implementation (Hamdy, 2007). There are four telecommunications licensed operators: Zain, MTN, Canar, and Sudatel, which lead and provide telecommunication services.  The services started in the '90s to introduce technology in the country. In 1993 the first mobile operator began its journey in Sudan by launching its activities at the beginning of 1997. The mobile services activities introduced the country to the Global System for mobile communications. Global System for Mobile Communications (GSM) networks made Sudan the fourth country in North Africa that adopted and launched mobile services in Africa (Sudatel Telecom Group, 2022).

Internet services technologies entered Sudan in 1998 by Sudan telecommunication company in collaboration with the Sudan corporation of broadcasting and television as a dial-up service. In addition, Sudan telecommunication company introduced 2.5G broadband wireless services and upgraded to 3G technologies in 2007 (The European Space Agency, 2015). As a result, in 2003, two leading companies managed to provide network coverage to 750 thousand of customers over time. Since then, the customer base has increased to over 13 million in partnership with Ericsson and Huawei as the ICT suppliers. Today, technology towers increased their capacity to cover more than 150 cities in Sudan, and the services have expanded to launch 4G services (LTE) over the larger cities in Sudan (Zain, 2021). As a result, Sudan has a well-equipped ICT infrastructure following regional standards (Sudatel Telecom Group, 2022).

With the development of ICT, the market in Sudan has witnessed a significant advancement in mobile services adoption and utilisation, particularly during the period 2011 to 2018, where the number of mobile subscribers increased from 18.3 million to 28.7 million in 2017—providing mobile coverage to 80% of the country (Ministry of Finance and Economic Planning, 2019). Although mobile communication technologies stimulate growth and development, this is only possible with a sound understanding of how to stimulate adoption and use of

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application. With this is mind the study, and given the background on the relevance of health applications, this study set out to investigate factors that influence maternal mobile application adoption and utilisation.

## 1.3    Research Problem

Mobile health (m-health) technologies are rapidly growing since they gained attention worldwide due to their capability to transform healthcare services by providing digital solutions and improving health quality and outcomes. However, the literature indicates that diffusion, adoption, and effective use of technology are not simple. Broad-scale adoption, especially in low socio-economic environments, is slow (Alaiad, 2019).

In the field of maternal health, mobile health interventions have demonstrated success in enhancing the access and delivery of maternal services. However, much more needs to be done in developing countries to ensure that modern ICT benefits are realised.

Sudan's mobile device usage rose from 52% to 72% between 2010 and 2018, supporting the UN's view that ICTs are essential for achieving sustainable development goals (International Telecommunication Union, 2021; Taylor, 2023). Targets 3.1 and 3.2 of SDG 3 - Good Health and Well-being, which aim to reduce maternal and child mortality rates, are particularly relevant to this study (United Nations, 2022).

However, in developing countries, minimal effort has been made to understand the pre-conditions for the effective adoption of ICTs, such as mobile applications, in the context of maternal health. There is no evidence in the literature regarding the factors, in a typical developing country setting, that influence pregnant women's perceptions towards the adoption of technology and how that influences their adoption and utilisation of maternal health mobile applications. This is an essential first step in advance of developing actual applications to support the achievement of maternal health targets.

## 1.4    Research Question and Objectives

This study aims to explore the perspectives of pregnant women in Sudan towards adopting mobile technology to improve access to maternal healthcare services and what factors associated with those perceptions affect women's usage decisions.

The primary research question is:

*What factors affect perceptions of pregnant women towards the adoption of maternal health mobile applications in Sudan?*

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In pursuance of the primary question, the following research objectives were identified:

- To identify a suitable framework to investigate the factors that affect pregnant women's perceptions towards the adoption and utilisation of mobile technology in maternal health.
- To develop an instrument based on an appropriate theoretical framework to investigate mobile application adoption in Sudan settings.
- To identify the factors that affect pregnant women's perceptions of adopting maternal health-related mobile applications in Sudan.
- To make recommendations on how maternal health mobile applications could be successfully implemented in a developing country context.

## 1.5    Delineation: The scope of the study

This study was conducted in Khartoum, the capital city of Sudan. Therefore, the findings may be limited to the population of Khartoum state only and may not necessarily represent the whole country. Future research at the state level could provide a complete view. Corona-Virus (COVID-19) restrictions have recently been lifted. However, because the participants were pregnant women, COVID-19 measures remained in effect in the course of the study. This impacted communications and many clarifications had to be made to ensure that participants understood the questions clearly. Language was another limitation, as the questionnaire which was developed in English had to be translated into the local language, Arabic. Furthermore, a minority of the participants were using m-health applications and answered the questions based on the researcher's definition of m-health applications. This was a limited scope qualitative study (mini-thesis) and thus a small sample size (16 participants).  In addition, some participants did not have smartphones and were unaware of the existence of m-health mobile applications.

## 1.6    Significance of the study

The protentional of mobile health (m-health) technologies can transform the delivery of healthcare in developing countries such as Sudan. Moreover, m-health enables the development of solutions to tackle health problems and provide sustainable solutions. Therefore, further investigation of the adoption of mobile health applications in the Sudanese context is important, as a lack of information in this field limits and impedes the adoption of m-health technology. This research can provide new insight into the factors influencing the adoption of m-health applications, particularly among pregnant women in a developing country, and how various

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factors affect their adoption and usage of m-health applications. With a focus of the pregnant women expectations, preferences, and perspectives of the adoption of mobile technology. This study will also add to the body of academic knowledge relating to the perspectives of pregnant women's m-health applications and use. The findings of this study will help to inform and implement appropriate m-health interventions in the field of maternal healthcare, potentially leading to increased or successful adoption and uptake of ICT, specifically among pregnant women in Sudan. Ultimately, a higher adoption rate of m-health among pregnant women may help reduce mortality rates among mothers and infants. It will also reduce the cost and pressure on healthcare systems as it supports early detection of possible complications and may assist pregnant women in avoiding harmful practices such as taking certain drugs with dangerous side effects.

## 1.7    Layout of the dissertation

The thesis presents research on mobile technology adoption for improved maternal healthcare in Sudan. To answer the main research question, "*What factors affect pregnant women's perceptions of adopting maternal health-related mobile applications in Sudan*?" the thesis is structured into five chapters, which are explained below:

**Chapter 1: Introduction and Background**

Chapter one presents the background of the thesis. This chapter provides the research topics that this study will investigate. In addition, the research problem, primary research question, objectives, scope and significance of this study are set out.

**Chapter 2: Literature Review**

This chapter reviews the literature on previous research that explores the adoption of mobile technology to improve maternal healthcare services in low-income countries. The literature starts by examining the role of technology in delivering healthcare services to improve the healthcare field, as well as introducing the development of technology adoption in healthcare and the subsets of electronic health (e-health), including the mobile health technologies interventions in maternal health. Furthermore, this chapter reviews the main technology adoption models and theories applied in investigating user adoption of new technology and services. In addition, the theoretical framework that guides this study, viz Unified-theory of Acceptance and Use of Technology (UTAUT), is discussed. Moreover, a subsequent discussion related to the applications of the technology adoption theories in e-health is also discussed.

**Chapter 3: Research design and methodology**

This chapter outline the research methods that were followed in this study. It introduces the qualitative research methods that guide this study and describes the research design method, a case study design chosen for its social science and natural context characteristics and sampling. A section on the development of the instrument and data collection process is illustrated in this chapter, including the site where the study was conducted and the target population of pregnant women who attend Dream specialised maternity hospital in Khartoum city. This chapter will also discuss the content analysis method as the data analysis process used in this study, using the UTAUT model as a framework guiding this study. Finally, the researcher also discusses the qualitative analysis of this study, which was performed through the Atlas.ti software for qualitative data analysis to create thematic codes.

**Chapter 4: Research findings and discussion**

This chapter represents the research findings that were gathered by interview guides. This chapter commences by presenting the demographics of the interviewees. The second section presents the thematic outcomes, categories, and concepts derived from the qualitative data analysis. The main research findings are based on the Unified-theory of Acceptance and Use of Technology. Each theme presented with a discussion on the findings of this study in relation to the research question: *What factors affect pregnant women's perceptions of adopting maternal health-related mobile applications in Sudan*?

**Chapter 5: Conclusions and recommendations**

The final chapter presents a discussion on the achievement of the research objectives. It is followed by summarising the key findings related to the factors influencing the adoption of m-health applications among pregnant women in Sudan. Finally, before concluding the dissertation, this study's recommendations, conclusions and limitations are summarised.

**1.8    Chapter Summary**

This chapter presented the study's background, discussing the importance of achieving healthcare services delivery for all and the vital link between technology that aids in reaching sustainable healthcare coverage and driving progress. This chapter in the main, made a case for investigating pregnant women's perspectives towards using mobile technology to improve maternal healthcare. The next chapter will introduce the literature review, presenting previous similar studies and the theoretical framework that led the study, which is the UTAUT adoption model compared to the main technology acceptance theories.

# Chapter 2: Literature review

## 2.1 Introduction

The previous chapter outlined an overview of the study background, objectives and research question, and topics that discuss the role of technology in transforming healthcare services delivery for all and the importance of technology in reaching sustainable healthcare coverage and driving progress. This chapter reviews the literature from previous research related to the adoption of mobile technology to improve maternal healthcare services in low-income countries. Furthermore, this chapter commences with a brief discussion of e-health. Then, it introduces the development of technology adoption in healthcare and the subsets of e-health, including the advancement of mobile health technologies, specifically the interventions in maternal healthcare. Also, this chapter reviews the main technology adoption models and theories applied in investigating user adoption of new technology and services. Furthermore, this chapter includes a section on the application of the Unified-theory of Acceptance and Use of Technology (UTAUT) model as the theoretical framework that guided the study. The last section provides a subsequent discussion on the applications of the technology adoption theories in e-health to investigate the user acceptance of the new technology.

## 2.2 Overview of e-health

Electronic health (e-health) refers to health services and information delivered through the internet and related technologies (Sendlhofer et al., 2018). Moreover, e-health is a broader term that includes more than technology implementation. It is an approach to thinking, a commitment to global networked thinking in order to transform healthcare services through the use of technology (Sönnerfors et al., 2020). With the advancement of information technology, e-health has resulted in the availability of healthcare services anytime, anywhere, as well as the connectivity to access and use healthcare services (Kiberd et al., 2018). Furthermore, this advancement has enabled the development of solutions to tackle health problems by using technology to provide a remote diagnosis of diseases for rural areas patients, make informed decisions, and provide medical education and training for health professionals (Messiah et al., 2020). As a result of these advances in e-health, there have been considerable changes in healthcare that allow for smarter, successful technology initiatives to improve patient outcomes (Polillo et al., 2021).

The successful technology initiatives have increased the demand to ensure the sustainability of e-health progress and to deliver public health and health services in a more strategic and

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integrated manner (Fanta & Pretorius, 2018). Howarth et al. (2018) indicate that the utilisation of digital health has a positive effect on health-related outcomes and users' health behaviours. Moreover, the expansion of e-health is associated with the current evidence on their cost-effectiveness and the expected benefits of innovative interventions (Hickman, Clochesy & Alaamri, 2021).

There are several examples of e-health applications that are improving healthcare services. For instance, Ittefaq and Iqbal (2018) state that in Pakistan, digital health services provide an online platform to facilitate healthcare communication between patients and health providers. Also, Green (2022) explainthat adopting e-health improved cancer quality of care services through a cancer-reporting program as a part of the healthcare system. The e-health interventions have also been applied in medication management to support patient adherence via a computer-assisted history-taking system to capture patients' data and improve the quality of healthcare services and health education (Abejirinde et al., 2018).

Health informatics applications provide interventions where geographic distance is a barrier to healthcare services delivered in the form of telemedicine solutions (Kissi et al., 2020). For example, telemedicine services provide access to healthcare services in maritime and offshore settings through radio consultations with picture and video conferencing (Wang et al., 2019). Similarly, the services expand to bridge the gaps in rural areas and enable patients to access healthcare services through the integration of tele-stroke technology, where an off-site neurologist evaluates and treats stroke patients through audio-visual systems that allow physical examination from a distance (Hossain et al., 2019).

## 2.3 Mobile technology in healthcare

Mobile health (m-health) can be considered a subset of e-health for delivering healthcare services. The World Health Organization (WHO) define m-health as the medical and public health practices supported by mobile devices such as mobile phones, wireless devices, patient monitoring devices and personal digital assistants (Jemal et al., 2022; World Health Organization, 2018). Moreover, Trude et al. (2021) state that mobile health interventions are a subset of e-health technologies linked to mobile technology and applications. Nwolise, Carey and Shawe (2020) indicate that the development and applications of m-health have reached different sectors in the healthcare field, such as cardiology, diabetes, obesity and maternal health in monitoring, managing and preventing diseases and medical conditions. Furthermore, evidence proves that m-health applications are promising tools for patient empowerment by

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allowing them to engage with their health care by using a medium for delivering health information (Musiimenta et al., 2021).

Digital health interventions have the potential to support cost-effective health promotions and awareness for specific groups, which can increase the patient's engagement with the technology (Shimpi et al., 2021). According to Gambier-Ross, McLernon and Morgan (2018), mobile technology has been utilised in women's health applications such as fertility trackers, enabling women to track their health. Buchanan et al. (2021) point out that in low-resource settings where internet connectivity is unavailable, mobile health interventions take place as health education tools by empowering patients by sending Short Message Service (SMS) messages to provide them with the needed health information. Furthermore, m-health applications have been used for medication adherence, whereas daily SMS-based texts are sent to patients as a reminder for medication. The results of this study showed significantly improved adherence rates (Hoque et al., 2020). In addition, Erfannia et al. (2020) demonstrate that using mobile health interventions had shown a positive effect on patients' self-management.

**2.4 Utilisation of mobile health applications in maternal health**

In the area of women's health, smart technology is used to reduce maternal mortality rates by identifying the gaps in different maternal health areas (Prinja et al., 2018), such as unplanned pregnancy and unsafe abortion, in order to improve maternal health (Indriani et al., 2020). A number of m-health applications are playing a role in health promotion by performing as health education tools to promote maternal health services (Nyang'echi & Osero, 2021). For instance, in Belgium, m-health interventions support pregnant women during and after pregnancy. These interventions reduce pregnancy and birth-related complications by promoting a healthy lifestyle focusing on physical activity, weight, diet and mental health by providing coaching sessions through health tracker application (Kenny et al., 2020). Chi and Urdal (2018) argue that health education interventions have empowered pregnant women and positively influenced their health behaviours. In Ethiopia, health education interventions have resulted in pregnant women's adherence to the recommended clinical visits (Gebremariam et al., 2020).

Health education interventions also serve as a gateway in driving developing countries towards universal health coverage. Mehl et al. (2018) present arguments to emphasise the potential of m-health applications in improving maternal health as a subset of achieving health coverage goals. Based on the foregoing, there is ample evidence that mobile applications have been used

effectively in various areas of maternal health. This is indicative, therefore, that m-health applications such as maternal digital interventions do indeed have the potential to support improved maternal health outcomes as a sub-goal of the universal health coverage objectives.

The preceding section provided insight into e-health and m-health applications and included health interventions. The literature provides evidence that m-health applications in the context of maternal health can decrease pregnancy-related complications. The succeeding section is set out to discuss the technology adoption models to identify a suitable framework to investigate the factors that affect pregnant women's perceptions towards the adoption and utilisation of mobile technology in maternal health.

## 2.5 Technology adoption

Technology has been one of the main factors that led to human progress in different fields. The spread of technology over time has increased the adoption of technology and raised awareness towards it. As the adoption requires active technology users, the adoption process starts with introducing the innovation, followed by different stages that aid the adoption and usage. The following sections provide a further discussion, briefly define technology adoption and discuss its concept, technology adoption in healthcare and the adoption of mobile technology.

### 2.5.1 The concept of technology adoption

Chandrasekaran, Katthula and Moustakas (2021) define technology adoption as the phase of technology diffusion in which an organisation or an individual decides to select a technology for use. Rogers (2003:117) defines technology adoption as a decision of "full use of an innovation as the best course of action available". Furthermore, Tao et al. (2020) divide the technology adoption process into three phases: awareness, trial and continued adoption of technology. Each stage represents an essential part of the technology adoption process. In the awareness phase, familiarising users with the value of technology adoption is the most important step to adopting the innovation. The second phase is to confirm the technology acceptance, which guarantees the technology adoption process. Therefore technology adoption starts with the user's awareness of the technology, followed by acceptance and full use of that technology (AlHogail, 2018). Furthermore, technology adoption has been studied since the 1970's and the importance of technology became evident when (Venkatesh et al. 2003) found that users were not benefiting from technology. Furthermore, understanding and identifying why people do not adopt and use technology is one of the key area in IS research (Thielmann, Hoving & Cals, 2023).

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### 2.5.2 Technology adoption in healthcare

Adopting technology in the healthcare field has created new ideas, services, structures and solutions to improve the field. The diffusion of technology has expanded to healthcare, and it has been introduced in managing and processing healthcare data by providing various applications under the concept of e-health, such as telemedicine and patient electronic health records, to support clinical services (Turan & Koç, 2022). As such, the utilisation of technology has introduced interventions in order to improve healthcare service delivery and quality (Dai et al., 2019). Broomhead et al. (2021) indicate that globally the adoption of technology into healthcare is rapidly increasing and remodelling healthcare services. This remodelling can be shown in the ability of technology to deliver timely, relevant and useful information that improves healthcare quality and outcomes (Jansen-Kosterink, Broekhuis & van Velsen, 2022).

### 2.5.3 Mobile technology adoption

The advent of mobile phones and their diffusion made humans adopt technology into their daily lives and depend on it (Sam, 2021)**.** Technology advancements have transformed mobile phones from limited functional devices into smart devices that combine various applications such as online payment, health tracking, shopping, time management and airline self-services (Hasan, Sultana & Bao, 2022). The diffusion of mobile technologies has provided a platform for communication to perform various functions from anywhere at any time (Ragesh et al., 2020). Furthermore, the multi-functionality made mobile phones one of the most central technologies of the 21$^{st}$ century (Zhang & Zaman, 2020). The multiple features of mobile phones have made them important devices in different domains because they make life more convenient (Singh & Samah, 2018).

Mobile applications are increasingly being used as healthcare tools and will most likely become a substitute for a face-to-face consultation with a healthcare professional (Lang & Zawati, 2018). Moreover, m-health applications have become an essential part of the healthcare system due to their promising potential, which allows patients and health providers to access and share health information remotely through cloud computing platforms (Alnuaimi et al., 2019). According to Lorenzetti et al. (2022), mobile applications have become familiar in healthcare settings as it has contributed to many clinical aspects. In addition, Dol et al. (2022) indicate that smartphone technologies have been adopted in various healthcare domains, resulting in increased patient opportunities for health education and management.

There are several examples of mobile applications in health care. For example, mobile health applications have performed as post-surgery recovery evaluators to track patients in their recovery period. Greenberg et al. (2022) indicate that mobile health applications are used for addressing preventive and treatment behaviour among Human Immunodeficiency Virus (HIV) patients to positively influence their health behaviours and reduce HIV-associated risks. In mental health, mobile health intervention for people with a history of homelessness homeless history to monitor and improve their physical and mental health-related outcomes (Rhoades et al., 2019). Mobile health applications have contributed to addressing the burden of chronic diseases. For example, an intervention was developed in Bangladesh for chronic disease management among the youth population (Morrison et al., 2022).

The preceding section discussed several examples of m-health applications in healthcare. The next section will discuss the various factors that impact m-health applications use.

## 2.6    Factors that affect the usage of mobile health applications

In the information technology (IT) age, mobile technologies developed for healthcare settings provide several services, such as health education, diagnosis, health tracking, and clinical decision-making. However, the adoption of technology in healthcare is associated with several factors that form barriers to adopting and utilising digital health technology (Palacholla et al., 2019). Given the significant gap in research in adoption factors of m-health applications in the context of Sudan, multiple studies from other developing countries had to be used. To support the subsections of the adoption factors, the findings of Zakerabasali, et al (2021), Addotey-Delove et al (2020) and Gagnon et al (2016) were considered. However, these authors grouped the subsection into individual, technical, organisational and contextual. Yet, for this study the groupings of the subsection were drawn from Kesse-Tachi, Asmah & Agbozo, 2019, as this focuses more on an individual, personal level rather than technical, organisational and contextual levels. Since m-health is a part of e-health, the groupings are applicable.


All these factors influence technology adoption for the users to replace the traditional methods and accept the new digital health interventions to improve their health outcomes (Kesse-Tachi, Asmah & Agbozo, 2019). The factors are divided into five: Behavioural factors, socio-economic factors, socio-cultural factors, demographic factors and user perception-related factors.

*Behavioural factors*

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Behavioural factors refer to factors which impact people's behaviours, such as user beliefs, behavioural intentions, confidentiality and privacy concerns (Taboada et al., 2021). Moreover, Alanezi (2021) explains that behavioural factors have been found to influence people's attitudes toward accepting technology. Appiah et al. (2019) indicate that behaviours and attitudes are crucial to the intentions of the use of technology. For instance, users' beliefs, cultural values and social influence are significant factors that impact individual behaviour and attitude, affecting the adoption of technology.

*Socio-economic factors*

Goedhart et al. (2019) illustrate that socio-economic factors are associated with social status and occupation, and the most common factors are the cost of usage and education level. Therefore, these factors influence the usage intentions of mobile health applications. Moreover, Van Velthoven and Cordon (2018) emphasise that healthcare systems are linked to the economic, political, social and legal situation. Therefore, the adoption of technology into healthcare is influenced by the socio-economic status as a result of the interaction of the healthcare system with all the above. Weiss et al. (2018) state that income and education as the socio-economic factors that impact the access to and use of technology.

*Socio-cultural factors*

Studies have shown that gender inequalities influence the adoption and usage of technology, as men are prone to adopt technology. According to Venkatesh et al. (2003), women are more anxious than men regarding technology usage, and males are frequent internet users. Moreover, gender is also a significant factor in determining the intentions of adopting new technology, as it has been found that men adopt technology more compared to women (Na, Lee & Yang, 2021).

Magugu et al. (2018) utilised the Unified-theory of Acceptance and Use of Technology (UTAUT) model in their study. They concluded that the performance expectancy construct is controlled by gender as a significant influencing factor that males are more likely to use mobile technologies than women. Literature proved that the gender gap affects females negatively as they face technical challenges and have a negative attitude towards utilising technologies, which are influenced by their culture and community beliefs (Kirkwood et al., 2022).

Furthermore, from another perspective, gender inequality in rural communities can hinder women from using technology. In addition, cultural factors that include cultural values and traditions significantly impact mobile technology usage (Peltonen et al., 2018). Bhattarai et al.

(2022) note that cultural beliefs hinder women from accessing technologies as they are expected to take responsibility for the family, which leaves them with no time to use technology following the rules of households. In developing countries, the traditions empower men with the ability to make decisions as men are seen as the powerful member of the family, which give women less power to decide and engage. Therefore it can be noted that a gender gap is a real concern that influences the adoption and access to technologies (Islam & Inan, 2021).

*Demographic factors*

Demographic factors show how gender and age differences affect people's perceptions of the adoption of mobile technology (Qan'ir et al., 2021). Hossain, Quaresma and Rahman (2019) found that demographic factors, including gender, age, and marital status, play a role in technology adoption as it has a significant influence on the acceptance and usage of technology. In particular, age affects the adoption of technology. Specifically, people of different ages tend to have different behavioural intentions towards adopting mobile health technologies (Zhao, Ni & Zhou, 2018).

*User perception-related factors*

Alcoba et al. (2018) describe user perception-related factors as the individual's perspectives towards the new technology. Also, the perceived service quality defined as the customer's assessment of the overall superiority or excellence of the service (Zeithaml, 1988)and ease of use significantly impact the user's adoption intentions of the technology. Putra (2018) points out that the most common factor in this category is social influence defined as "the degree to which an individual perceives that important others believe he or she should use the new system." (2003:451), which is individual social relationships and social engagements, as well as perceived usefulness. Perceived usefulness is defined as "the degree to which a person believes that using a particular system would enhance his job" (Davis, 1989:320) and perceived ease of use is defined as the degree to which system user believes that technology usage would be free of effort. This, in turn, has a positive influence on individual attitudes toward the adoption of mobile technology. For example, Samadbeik et al. (2020) reveal that users acceptance of technology is affected by the perceived usefulness does influence their acceptance of m-health technology.

The succeeding section will discuss the main technology adoption models used in the healthcare sector. Thereafter, a table demonstrating a summary of the models will be depicted. This is done to identify which model is best suited to answer the research question.

## 2.7 User technology acceptance and adoption models

Investigating user acceptance towards new technology, services, and goods are critical in identifying the future of the interactions between users and technology (Venkatesh et al., 2003). Many theories and models have been developed to understand and investigate the factors affecting users' acceptance of technology (Liu & Miguel-Cruz, 2022). According to Terblanche and Kidd (2022), technology adoption models attempt to identify and explain users' behavioural intentions with similar concepts and variables but different methodologies in explaining the technology acceptance phenomenon. Technology adoption models and theories analyse the factors that influence the acceptance and use of new technology (Lulin et al., 2020). The following sub-sections discuss the selected theories that are prominent in the literature.

### 2.7.1 *Technology Acceptance Model (TAM)*

The technology acceptance model (Davis, 1989) was developed to identify the determinants involved in technology acceptance and examine the technology usage behaviours to provide a theoretical explanatory model. The Technology Acceptance Model posits that there are two factors that determine whether technology will be accepted by its potential users. It has two constructs: perceived usefulness, and perceived ease of use (Davis, 1989).

The technology acceptance model based on the theory of reasoned action examines the linkage between the user's perceptions and technology usage (Chan et al., 2022). The model was developed to explain the technology acceptance and usage behaviours (van Oorschot, Hofman & Halman, 2018). Moreover, the technology acceptance model is considered the first theory that attempts to explain user acceptance by concentrating on the perceived usefulness and ease of use of the technology (Ramsden et al., 2022). In addition, the technology acceptance model factors of perceived usefulness and ease of use are significant determinants of user behaviours towards acceptance and use of technology (Post et al., 2022).

### 2.7.2 *The Unified-theory of Acceptance and Use of Technology (UTAUT)*

The Unified-theory of Acceptance and Use of Technology was developed by Venkatesh, Morris, Davis, and Davis in 2003. UTAUT is the most up-to-date model that explains attitudes towards technology acceptance and use (Rouidi, Elouadi & Hamdoune, 2022). The theory introduced four critical factors of acceptance and utilisation, which are performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh et al., 2003). Moreover, UTAUT integrates eight models, which are the technology acceptance model (TAM), the theory of planned behaviour (TPB), a model that combines both the

technology acceptance model and theory of planned behaviour (C-TAM-TPB), the model of PC utilization (MPCU), the innovation diffusion theory (IDT) and the social cognitive theory (SCT) (Moura et al., 2020). Section 2.8 will discuss the UTAUT in detail by providing the constructs that make up this model.

### 2.7.3   Social Cognitive Theory (SCT)

The social cognitive theory (SCT) was developed by Bandura in 1986, and it is described as the most powerful theory of human behaviour (Bandura, 1986). The social cognitive theory is a social behaviour change theory widely applied in different studies that explore people's health behaviours (Adalia et al., 2021). Moreover, the social cognitive theory focuses on individual knowledge to explore the adoption of technology by its determinants of behaviours: self-efficacy, expectations, reinforcements, observational learning and reciprocal determinism (Lee, Lee & Shin, 2020). Furthermore, the theory assumes that individual behaviour towards technology adoption is determined by environmental, behavioural and personal influences (Lee et al., 2018).

### 2.7.4   Diffusion of innovation theory (DOI)

The diffusion of innovation theory (DOI), developed by Rogers in 2003, was applied in previous studies that explained how people translate new ideas, such as disease knowledge and new treatment skills, into real-world applications (Roger, Shulin & Sesay, 2022). Moreover, the theory explains the adoption of technology by focusing on the main elements, which are communication, time, channels and social system and how they influence the adoption of innovation (Azuh et al., 2020).  Also, the theory has five constructs: relative advantage, trial-ability, complexity, computability and observability that influence an individual's attitudes towards acceptance of technology (Furusa & Coleman, 2018). Furthermore, the table below summarises the main technology adoption theories and their constructs, the measurable variables, the logical connection between the constructs, the

phenomenon, and the limitations of each theory.

**Table 1: Summary of main technology adoption models and theories**

Table 1 presents a summary of the four prominent models of user acceptance. This includes the key variables of the model, measurable indicators, limitations, and examples of research that applied these models in e-health and m-health studies

| Model | Key Variables | Measurable indicators | Claimed Causality/Association | Limitations | Examples of recent applications in e-health / m-health |
|---|---|---|---|---|---|
| **Social Cognitive Theory (SCT)**<br><br>**(Bandura, 1986)** | Reciprocal Determinism<br><br>Behavioural Capability<br><br>Observational Learning<br><br>Reinforcements<br><br>Expectations<br><br>Self-efficacy | Individual's behaviours towards SCT constructs. | Expectations and self-efficacy affect the acceptable usage of technology. | Cognitive approaches neglect the effect of motivational factors and other personal constructs on the individual's information acquisition (Oyibo, Adaji & Vassileva, 2018). | Mobile health intervention for people with homeless history to monitor and improve their physical and mental health-related outcomes (Rhoades et al., 2019).<br><br>Gain a better understanding of patients' perceptions towards e-health services implementation for health promotion (Vollenbroek-Hutten et al., 2018). |
| **Technology Acceptance Model (TAM)**<br><br>**( Davis,1989)** | Perceived Usefulness (PU)<br><br>Perceived Ease of Use (PEOU). | Individual's perception and Attitude towards usability and flexibility of use. | The usefulness and ease of use of technology affect the user's intentions to adopt the new technology. | TAM depends on users' behavioural intentions to explain their perceptions towards technology. However, some researchers argue that before implementing the assessment, there is not enough exposure to technology.<br>(Wahbeh et al., 2018) | Mobile health intervention in Bangladesh for chronic disease management among the youth population (Morrison et al., 2022).<br><br>Investigation of implementing mobile health intervention to address HIV-infected population health behaviours (Brooks et al., 2020). |

| The Unified-theory of Acceptance and Use of Technology (UTAUT)<br><br>(Venkatesh, 2003) | Performance expectancy<br><br>Effort expectancy<br><br>Social influence<br><br>Facilitating conditions | Individual's perception of UTAUT four constructs. | The performance expectations, effort expectancy, social influence, and facilitating conditions affect the acceptance and usage of technology. | It has limitations in its relationship between individuals' behaviour and the use of technology as it does not consider more external factors in different technology areas (Dwivedi et al., 2019). | Mobile health intervention to record healthy body functions such as blood pressure (Nau et al., 2021).<br><br>Understanding community-dwelling older individuals' intentions towards the use of e-health applications (Switzer & Schroder, 2019). |
|---|---|---|---|---|---|
| **Diffusion of innovation theory (DOI)**<br>(Rogers, 2003) | Relative advantage<br>Complexity<br><br>Compatibility<br><br>Trial-ability<br><br>Observability | Individual's attitudes towards the five constructs of DOI | The innovation advantage, complexity, compatibility, trial basis ability and its visible results on the community affect the adoption and acceptance of the innovative technology | The theory examines the technology only in a socio-cultural context like cultural values, social relationships, and beliefs (Lulin, Owusu-Marfo, Antwi et al., 2020). | understanding the factors that impact patients acceptance and use of e-health innovations in a primary care clinic (Sampa et al., 2020).<br><br>Exploring doctors knowledge and attitudes towards e-health use in healthcare services delivery in private and government hospitals in Uganda (Binyamin & Zafar, 2021). |

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## 2.8    Application of the technology adoption theories in e-health

The technology adoption theories explain technology acceptance and provide insight into an individual's decision to use or reject new technology. In the e-health domain, a number of these theories are applied to investigate adoption and use. For example, Rhoades et al. (2019) indicate that social cognitive theory (SCT) has been applied in text-based intervention to increase physical activity by encouraging walking via motivational text messaging to promote self-monitoring behaviour of walking using pedometers and providing ongoing feedback. Furthermore, as e-health services are considered promising in the prevention and improving self-monitoring of patients, another study applied Social cognitive theory (SCT) as a behavioural change theory for a better understanding of older patients' perceptions regarding using e-health services for self-monitoring to take responsibility of their own health decisions (Kim & Han, 2021).

Moreover, the technology acceptance model has been widely used in different studies to assess the significant relationship between social, cultural and technological constructs with users' intentions to use m-health applications. For example, Morrison et al. (2022) applied the technology acceptance model (TAM) to identify the cultural factors that influence the adoption of e-health services in Bangladesh, in which perceived usefulness (PU) was a significant indicator in predicting e-health adoption. In addition, Nadal, Sas and Doherty (2020) reveal that the TAM model considers perceived usefulness and perceived ease of use constructs regarding patients' perceptions of their disease severity using m-health interventions as a self-management tool.

Furthermore, the Unified-theory of Acceptance and Use of Technology (UTAUT) was applied to identify the usage of mobile health-related technologies by doctors and their patients, aiming to investigate the factors contributing to their acceptance of the technology intervention (Philippi et al., 2021). Although Switzer & Schroder (2019) indicates that UTAUT has mainly been tested in healthcare, the study applied UTAUT to explore the model determinants of the intentions to use e-health for patients and health professionals to facilitate access to health information digitally where the constructs of UTAUT, specifically the performance and effort expectancy were relevant predictors of technology acceptance.

Binyamin and Zafar (2021) state that adopting e-health technology in professional practice in developing country settings can be explained by applying the diffusion of innovation theory

(DOI). The results explained professionals' attitudes towards accepting innovation by investigating the influence of DOI's five attributes.

Technology theories were developed over time, considering user needs and technological changes. Evidence shows that in the e-health domain, technology acceptance studies are being conducted constantly with the application of technology adoption theories and the influencing factors to determine users' behaviours and attitudes towards e-health adoption and usage.

### 2.8.1 Applying the UTAUT model to the study

As shown in section 2.7, the theories presented explains an individual's behaviours towards acceptance and use of the technology. Venkatesh et al. (2003) compared UTAUT with other technology adoption and found that the UTAUT model explained 69% of technology usage intentions, while other models explained approximately 40% of technology adoption intentions. In addition, the UTAUT is a comprehensive model that combines the other theories presented above. Dwivedi et al. (2019) indicate that the UTAUT is the most up-to-date model that explains attitudes towards technology acceptance and use.

The literature indicates that UTAUT has been tested widely in different fields and promises to be an excellent tool for analysing and explaining users' acceptance of health technology (Yu et al., 2021). Furthermore, Kim and Lee (2022) state that previous studies have confirmed that UTAUT is applicable to studying mobile technology in the healthcare context. Likewise, Ljubicic, Ketikidis and Lazuras (2020) emphasise that UTAUT constructs directly influence users' intentions to use e-health technologies.

Moreover, the theory was introduced with four constructs of acceptance and utilisation, which are performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FC) (Binyamin & Zafar, 2021). Jahanbakhsh et al. (2018) recognised perceived usefulness (performance expectancy) as the most important predictor of the user's behavioural intentions toward using e-health technologies. Aria and Archer (2020) revealed that over 18 studies cited perceived ease of use (effort expectancy) as one factor influencing m-health adoption. In addition, Schneider et al. (2020) investigated the social influence construct and concluded that it influences behavioural intentions, specifically in the context of e-health adoption. Facilitating conditions has a significant role in technology adoption. To emphasise Venkatesh et al. (2003) indicate that gender, age and experience of technology usage are moderating factors that influence users' behavioural intentions towards technology acceptance.

In line with the strength of the UTAUT model over other technology adoption models and the empirical evidence on its applicability and relevance of the model on e-health adoption studies, the model will be adapted in the study to enable a better understanding of pregnant women's perceptions towards adopting mobile health applications at Dream maternity specialised hospital.

## 2.9 Theoretical Framework

The Unified-theory of Acceptance and Use of Technology (UTAUT) model was used to study the adoption of mobile health applications among pregnant women in Sudan. The UTAUT model consists of four main constructs to determine the intentions of adoption and usage in one or more individual models (Venkatesh et al., 2003). Furthermore, the model explains the predictors of users' intention, which are performance expectancy, effort expectancy, social influence and facilitating conditions that have a role in directly determining user acceptance and usage. In addition, to the moderating factors of age, gender, voluntariness and experience.

The figure below (Figure 1) depicts the Unified-theory of Acceptance and Use of Technology (UTAUT) model
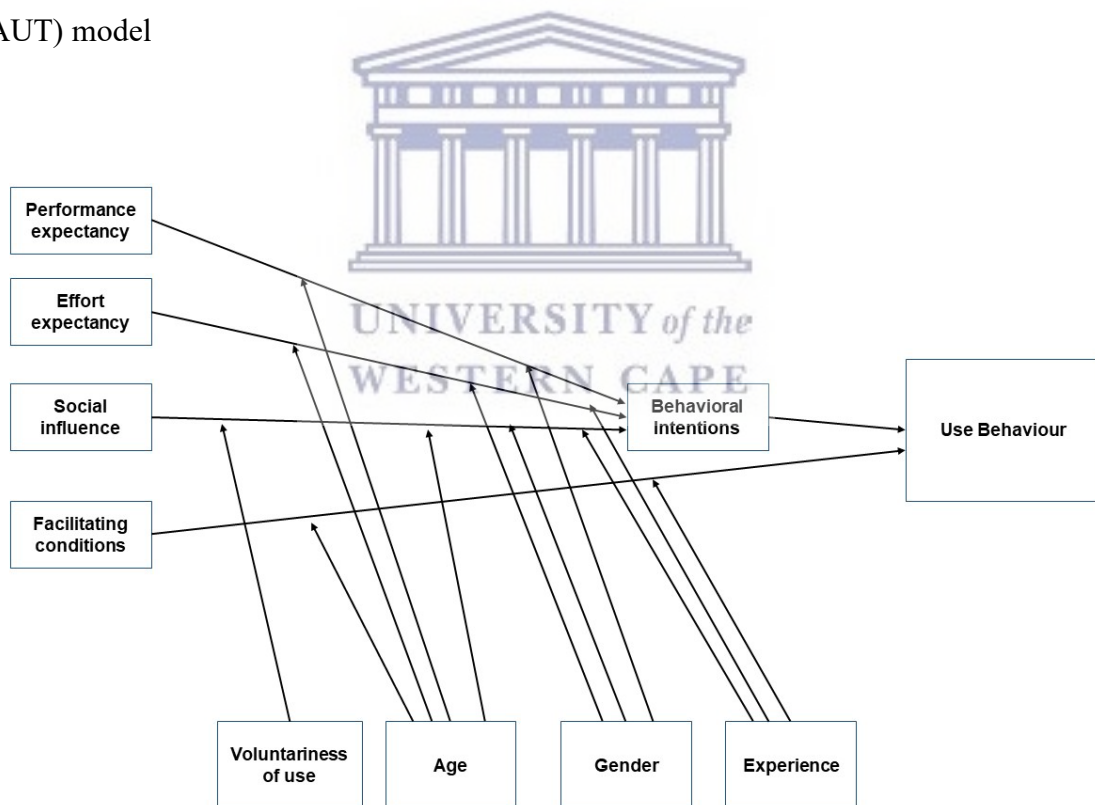


*Figure 1: Unified-theory of Acceptance and Use of Technology (Source: Venkatesh, Morris, Davis & Davis, 2003:447)*

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The UTAUT constructs are defined below:

- Performance expectancy (PE): Venkatesh et al. (2003) defines Performance expectancy as "the degree to which an individual believes that using the system will help him or her to attain gains in job performance" (2003:447). Jahanbakhsh et al. (2018) recognised perceived usefulness (performance expectancy) as the most important predictor of the user's behavioural intentions towards using e-health technologies. From another perspective, performance expectancy refers to the perceived usefulness of new technology, which is critical in explaining the user's behaviour towards adopting and using m-health technologies.

- Effort expectancy (EE): Effort expectancy is determined by several factors, including flexibility and usefulness of the technology and its user-friendliness (Nyesiga et al., 2017). Venkatesh et al. (2003) defines effort expectancy as the "degree of ease associated with the use of the system" (2003:450). The concept of ease of use describes how users believe technology usage is free from effort (Tahar et al., 2020). Previous studies have highlighted the efforts expected on m-health application usage as determinants of users' intentions. For example, Wu et al. (2022) revealed that users' willingness to use m-health applications without assistance to access healthcare services depends on time and effort, reflecting the technology's difficulties or ease.

- Social influence (SI): Social influence is "the degree to which an individual perceives that it is important that others believe he or she should use the new system" (2003:451). It directly determines the behavioural intention to use technology (Venkatesh et al., 2003). Moreover, Farzin and Fattahi (2018) highlighted that individuals usually choose what their friends and family adopt. Also, Klingberg et al. (2020) highlighted that women are affected by social relationships more than men. Venkatesh et al. (2003) explained that the positive correlation between social influence and individuals' attitudes towards adopting new technology is stronger among women.

Facilitating conditions (FC): are defined as "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). Moreover, facilitating conditions have a significant role in technology adoption among users, known as the dominating factors influencing individual behavioural intentions to adopt m-health (Udenigwe & Yaya, 2022).

## 2.10 Chapter Summary

Chapter 2 presented a review of the literature examining the adoption and usage of technology in healthcare as well as the success of digital interventions in driving healthcare services. The advancement of mobile technologies has created more opportunities to develop digital tools that improve healthcare. The m-health interventions succeeded in different areas of healthcare in providing easy, reliable and free-of-charge access to health information. Although previous studies present that m-health interventions successfully identified different maternal healthcare gaps as health education tools to promote maternal health services and support women during pregnancy and after delivery. However, there is evidence that the adoption can be influenced by different factors that form barriers to adopting and utilising digital health technology in developing countries' settings. In this chapter, the theoretical framework that guided the study is the Unified-theory of Acceptance and Use of Technology (UTAUT). The comparison of different technology acceptance models was applied to identify which model could investigate technology adoption in healthcare. The succeeding chapter will explain this study's research methodology and design.

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# Chapter 3: Research methodology

## 3.1    Introduction

The previous chapter discussed the extant literature on e-health and m-health and the main technology adoption models and theories in relation to healthcare. The factors that influence the adoption of m-health applications were also reviewed. The literature proved that m-health interventions successfully identified different maternal healthcare gaps. Performing as health education tools to promote maternal health services and supporting women during pregnancy and after delivery.

This chapter presents the research methods that were followed in this study. It introduces the qualitative research methods that guide this study. The section commences by discussing the research design, which is a case study design.  A section on the development of the instrument and data collection process is illustrated in this chapter, including the site where the study was conducted and the target population of pregnant women who attend Dream specialised maternity hospital in Khartoum city. This research methodology chapter will also outline the content analysis method as the data analysis used in this study, using the UTAUT model as a framework guiding this study. This section also discusses the qualitative analysis of this study, which was performed through the Atlas.Ti, a software for qualitative data analysis to create thematic codes.

## 3.2    Qualitative Case Study Research Design

Qualitative methods are known to be as comprehensive, explicit, and reproducible as possible (Booth, 2019). Qualitative methods help to gain insight into real-life experiences by generating rich data (Ash, 2020). This experiential insight will help to answer the "how" and "why" questions of this research, which is useful for assessing the less tangible outcomes (Constantinescu et al., 2019). According to Creswell (2014), qualitative data seeks to find the meaning people attach to a particular phenomenon. Furthermore, qualitative approaches gained attention across disciplines. The increasing interest in qualitative methods came from exploring the personal and cultural aspects of research (Ho, Wright & Parsons, 2021). Therefore, this study's nature is qualitative to generate rich data that will answer the research question and better understand mobile health technology adoption among pregnant women regarding mobile health technology at Dream specialised maternity hospital.

The research design reflects the study's aim of exploring pregnant women's perceptions of mobile technology adoption. Bourbonnais et al. (2020) remark that a survey on users' perceptions will always be exploratory. For exploring users' perceptions, the exploratory design, by its nature, focuses on collecting primary or secondary data via informal or unstructured procedures to gain additional insight into the phenomena (Venning et al., 2021).

In the qualitative explorative method, the open-ended questions and probing allow participants to answer in their own words and express their opinions. That is meaningful, rich, and explanatory (Marsh, Bush & Connelly, 2020). Therefore, the research design is exploratory in nature to collect relevant primary data that will provide a basis to answer the main research question.

Given the preceding, the research design for the study is based on a case study. According to Heale and Twycross (2018), a case study design is a research strategy that helps us understand a real-life phenomenon that utilises naturally existing information sources such as people and their interactions within the case's scope.

The case study also offers a flexible research strategy that enables an in-depth capturing approach and multiple perspectives of the phenomenon (Even Chorev, 2019). The case study design has flexibility, which is not offered in other qualitative methods. This degree of flexibility can enable the design to suit the case (Ebneyamini & Sadeghi Moghadam, 2018). Çelik Ertuğrul, Toygar and Foroutan (2021) noted that case study design could be a robust methodology to investigate a specific phenomenon intensively to identify factors, processes and relationships. In addition, the case study design gives breadth to explore the case sources and create values from the collected data (Zhu et al., 2020).

The case study design is used predominantly in social science. It is beneficial when investigating its natural context. However, it may not generate the best results when the phenomena are well understood (Nikolaidou et al., 2021). According to Berends and Deken (2021), exploratory cases can be descriptive and used to generate hypotheses for later investigation of the phenomena. A case study is the best resource to capture a situation's reality; ideally, it is in studies exploring people's perspectives to understand the phenomena under study (Eakin & Gladstone, 2020).

Henshall et al. (2020) indicated that the in-depth analysis of the case study design proved valuable, essential, and adherence to generate satisfying knowledge and the required validity that is difficult to achieve with other methods. Therefore, in this study, a case study design was

applied to explore pregnant women's perspectives towards using mobile health applications to improve maternal health. A case study design was chosen for its social science and natural context characteristics and sampling.

## 3.3    Unit of analysis

The analysis unit is one of the first steps in qualitative research, defined as the "who" or "what" for which information is analysed and conclusions made. Also, it is an integral part of the research linked to the research problem (Tuthill et al., 2020). Monteiro and Richter (2019) stated that in content analysis, it is crucial to decide on the units of sampling to units of analysis as an essential part of the research linked to the research problem. This study's analysis unit is the pregnant woman at Dream specialised maternity hospital that attends maternity services, particularly to follow up on pregnancy, to conduct interviews with them, explore, probe, and better understand their perceptions and behaviours towards mobile health application adoption and utilisation to improve access to maternal healthcare services.

## 3.4    Design of the Research Instrument

The interview questions were designed into five sections (See Appendix C). Each section contained questions that captured pregnant women's information and aligned with the UTAUT model constructs as the framework for this study.

Venkatesh et al. (2003) compared UTAUT with other technology adoption and found that the UTAUT model explained 69% of technology usage intentions, while other models explained approximately 40% of technology adoption intentions. The Unified-theory of Acceptance and Use of Technology (UTAUT) is a comprehensive model that combines the other models presented above. Dwivedi et al. (2019) note that UTAUT is the most up-to-date model that explains attitudes towards technology acceptance and use.

The literature indicates that UTAUT has been tested widely in various fields and is an excellent tool for analysing and explaining users' acceptance of health technology (Liu, Maimaitijiang et al., 2019). (Alam, Hu & Barua, 2018).  remarks that previous studies have confirmed that UTAUT is applicable to mobile technology in the healthcare context. Likewise, Bramo, Desta and Syedda (2022) emphasise that UTAUT constructs directly influence users' intentions to use e-Health technologies.

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Venkatesh et al. (2003) revealed that performance expectancy and effort expectancy are the main determinants of technology's intentions. Therefore, in this study, these two constructs were applied to predict pregnant women's behavioural preferences towards using mobile health applications to determine if the application performance and ease of use are facilitators for m-health adoption. Moreover, the social influence construct determines if others (relatives, friends) influence pregnant women's mobile health applications. Finally, the last construct determines other factors that facilitate technology adoption, such as mobile phones' affordability and the service's price, reliability of the mobile phone infrastructure, and confidentiality of information sent via application. Also, the interview process was recorded and documented with the approval of the study participants.

**Section A: Demographic data**

The first section (Section A) of the interview includes the demographic data. This section aims to obtain the pregnant women's background, starting with their questions on their demographics, age, education level, and marital status. Also, their technology background gave the interviewee a chance to explain their experiences with technology.

**Section B: Performance expectancy**

This section starts with a brief overview of mobile health applications, their features, and functionality to familiarise interviewees with the application and formulate their expectations. Examines the performance gains influence on pregnant women's behaviours and thoughts towards accepting to use of mobile health applications. As well as understanding the circumstances under which pregnant women use technology to search for health information. This section also allowed the interviewee to express their mobile health applications' expectations and their benefits from linking with the Researcher's features and functions.

**Section C: Effort expectancy**

This section examined pregnant women's expectations regarding the ease of use of mobile health applications. The questions allow the women to express their opinions about the ease of using mobile health applications and pose questions to encourage them to think about the benefits and support of using the application during their pregnancy.

**Section D:  Social Influence**

Section D intended to determine the social influence effect on technology adoption among pregnant women and if they are encouraged to use mobile health applications of others in their social network relatives and friends utilising the application.

**Section E:  Facilitating conditions**

Section E introduces the facilitating conditions that could be essential predictors towards mobile health application adoption.

- Digital literacy
- Affordability
- Confidentiality

This section posed questions to understand the existing facilitating conditions associated with pregnant women's behavioural intentions towards technology usage.

**Section F: Socio-cultural Factors**

This section explores the socio-cultural factors from gender differences in rural communities that give women less access to technologies. The questions are designed to encourage women to elaborate more on their traditions and cultural beliefs that slow the process of empowering women in these communities.

**3.5   Data sources, Sampling strategies and techniques**

In general, sampling techniques are divided into two main categories:

- Probability or random sampling involves random selection, which means that every item in the population has an equal chance of being included in the sample (Sadeghi Moghadam, Ghasemnia Arabi & Khoshsima, 2021).
- Non-probability or non-random sampling is often associated with case studies that focus on small samples and are intended to examine real-life phenomena (Taherdoost, 2016).

Purposive sampling, one of the non-probability sampling techniques, has been used. It is widely used in qualitative studies to identify and select a group that shares the same experience with a particular phenomenon (Lamba, Tonder & Raghavan, 2022). The technique also serves specific groups in mind, such as a small sample size, and it can capture a wide range of participants'

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perspectives (Ames, Glenton & Lewin, 2019). In addition, purposive sampling techniques may provide a broad range of attributes, behaviours, and experiences that provide greater insight into the phenomenon (Hui et al., 2020). A purposive sample characteristic is defined based on the study's purposes, and the more purposive the sample becomes, the many advantages of purposive samples (Andrade, 2020).

As the purposive sampling techniques allow widespread exploration, the sample size is determined by the data saturation core principle as it is the most commonly used to estimate sample size, which is referred to as the golden rule of qualitative research (Saunders et al., 2018) and is a criterion for judging when to discontinuing data collection.

In this exploration study, the sample size is sixteen interviewees, these were all recorded and utilised for transcription and analysis from Dream maternity hospital.

### 3.6   Data collection Techniques (Research Methods)

Data was collected through interviews with pregnant women at Dream maternity hospital to explore their perspectives towards mobile health applications. The participants are pregnant women who attend the hospital for maternity services. The researcher selected participants from outpatient clinics. The selection was random to achieve diversity in questionnaire responses to generate rich data except for mobile health application users. Moreover, Dream hospital's general manager conducted a meeting to introduce the researcher to the hospital staff. The meeting participants were the administration officer and assistant, health officer, head of the maternity department, outpatients' clinic's nurses, and security department head. The researcher provided a background of the study, and the staff asked questions to understand more about the research and mobile health applications. The staff expressed willingness to support the study and provided all the required sources.

The maternity nurses showed generous support while conducting the interviews and the hospital staff cooperated in setting up the environment to conduct interviews. Furthermore, the researcher was issued an entry authorisation to enter the hospital premises. The health officer reviewed the COVID-19 regulations guidance, and the researcher was legally required to comply with the regulations.

The researcher asked for an office to conduct interviews. The administrative officer showed cooperation and support. The hospital provided an office for the researcher to use for all research purposes. Also, nurses helped the researcher by advising on the most suitable days of

the week that the clinic receives many pregnant women. On Sundays and Wednesdays, outpatient clinics are always crowded with pregnant women travelling to the clinic from Khartoum. In addition, two of the famous gynaecologists in Khartoum operate on Sundays and Wednesdays.

The data collection process duration was two weeks. The interviews took place from the 15th to the 29th of November. The researcher introduced herself, followed by a presentation on the mobile health applications made to the pregnant women sitting in the waiting area. To enhance the utilization of m-health applications among pregnant women in Sudan, the study employed the concept of awareness. This involved demonstrating the advantages of utilizing technology by showcasing the diverse functionalities of the applications during interviews with the participants. The aim was to raise awareness and encourage greater usage of m-health applications. Next, women were asked to participate voluntarily in this study. Both researcher and the interviewees wore face masks and kept a distance of 1.5 to 2 meters.

After signing informed consent, individual one-to-one interviews were conducted. Twenty-five women were enrolled, but only sixteen were used as part of the study due to incomplete, unrelated information after transcription. Each interview was fifteen to twenty minutes, where a brief introduction was presented on m-health applications, their features, and their functionality.
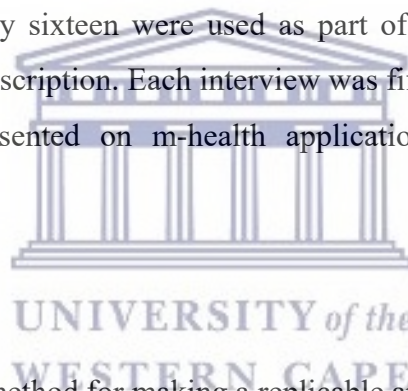
## 3.7   Data analysis

Content analysis is a research method for making a replicable and valid inference from data to describe the phenomena and build meaningful clusters comprehensively. The content analysis themes are also used in inductive or deductive coding, determined by the study's purpose (Mozersky, Friedrich & DuBois, 2022). Content analysis is considered a practical method applicable to numerous disciplines; it provides clarity and meaning to raw texts (Liu, Jacoby, et al., 2019). This study also takes an inductive approach, using the independent variables of the UTAUT as a lens. In explorative content analysis, all data sets are analysed to identify codes in primary data, where codes are organised into clusters attached to UTAUT theory constructs (Carmona, Baxter & Carroll, 2022). Moreover, the content analysis method is proven to help find similarities in categories as it is known to be conceptualized as a fixed, stable, and verifiable method in qualitative studies (Engstrom et al., 2022).

Furthermore, the inductive approach is recommended where there is not enough former knowledge of the phenomena; the method moves from the specific to the general so that particular instances are observed and then combined into a general statement (Smith-Macdonald et al., 2019). Inductive coding is a step that follows the formatting of the raw data collected from the interviews. Coding means identifying text segments and categorising them into relevant themes (Beresford et al., 2022). According to the UTAUT constructs, the analysis approach is inductive to analyse collected data guided by specific objectives to develop generalisations from interviewing pregnant women using mobile health applications. An inductive approach will also enable the developing of themes from the raw data generated from in-depth interviews, creating categories after reading texts to familiarise the content and understand the themes to code the commonalities (Skjott Linneberg & Korsgaard, 2019).

Moreover, the audio-recorded interviews were transcribed into separate documents for each interviewee. The analysis was performed using the Atlas.ti tool for qualitative analysis. It is known for its ability to explore data and use various functions to code and create links. In addition, it facilitates making meanings out of the raw data and provides data visualisation for the findings and interpretations (Flemming & Noyes, 2021). Moreover, Atlas.ti software codes qualitative text passages and facilitates comparison between interviews (Soilemezi & Linceviciute, 2018). In this study, interview transcripts were analysed using Atlas.Ti software by coding transcripts based on the UTUAT constructs along with a new theme, the sociocultural factors that emerged from the reviewed literature and findings. After that, codes are categorised accordingly.

The following steps were considered the main steps of content analysis of the qualitative data in this study. Each step includes a picture taken from Atlas.Ti software during the data analysis process for a better understanding of the data analysis process. The following section illustrates the steps of the interview transcripts analysis.

a) Interview transcripts were uploaded to the Atlas.ti software
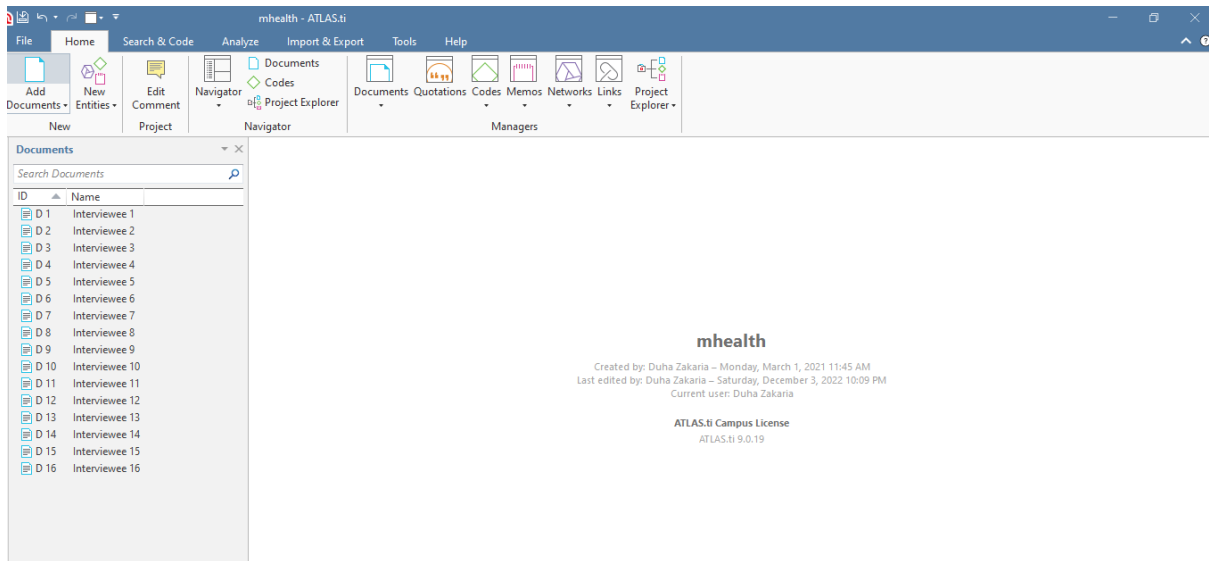


Figure 2: The interview transcripts listed in Atlas.Ti

b) Data segments were assigned into quotations and then labelled as codes based on the UTAUT model constructs.
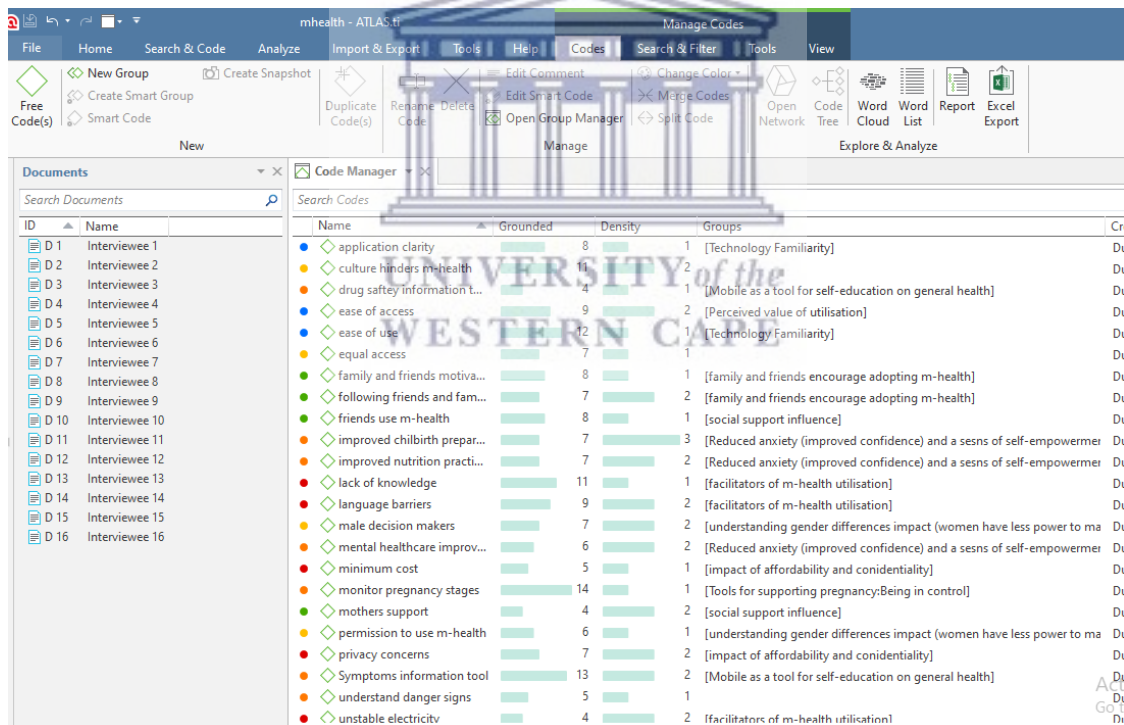


*Figure 3: List of the codes that emerged from raw data*

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c) After coding interview transcripts, similar codes were grouped into categories.
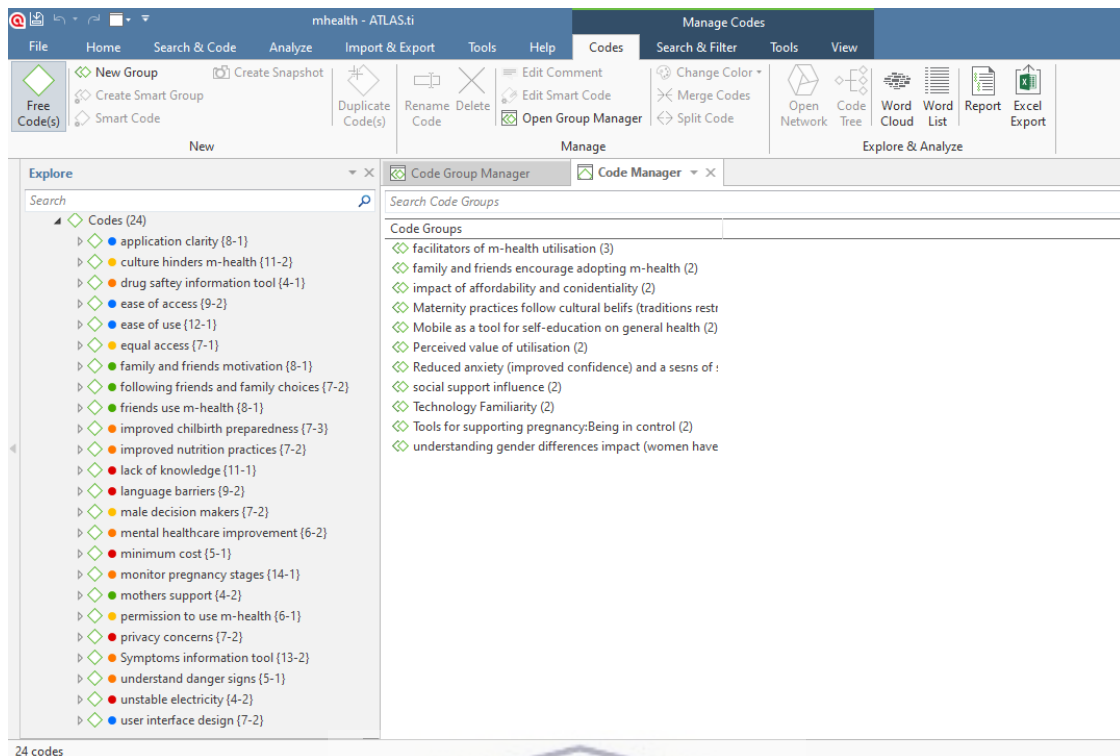


*Figure 4: Codes and categories*

## 3.8 Ethical considerations

Ethics in research defined as "the principles and guidelines that help us uphold the things we value" (Johnson and Christensen, 2018:101). Before conducting the research and the data collection, the project received ethical approval from the Biomedical Research Ethics Committee of the University of the Western Cape. The participants received an information sheet and consent form to request their participation in this study. The information sheet explained the research aim, interview duration which is from 20-30 minutes and that this interview will be recorded on a recording device to be transcribed into readable information. If at any point in the interview, participants are not comfortable for any reason, they may advise the researcher to stop the interview. Furthermore, participation in the study is completely voluntary and participants are free to withdraw at any time without any threat, penalty or detriment to their professional or personal capacity. In addition, participants who gives consent for participation in this study, will be required to participate in an interview with the researcher to discuss their views and opinions about the adoption of mobile health applications. Moreover, the participants had to meet specific criteria to be part of the study which is: had to be Sudanese, female, who are in the stages of pregnancy, resident in Sudan.

Ethical research practices were ensured by the process of official approval by the relevant ethics committee. Moreover, the anonymity of participants was ensured, such as name, address, employment or identity number. and no identifying elements were stated in discussions that could cause possible detriment to participants in their visits to the health centre. There was no risk or harm to the participants, no sensitive questions were asked. In addition, the collected data was stored in a google drive which can only be accessed by the researcher.

Written consent was obtained from participants to explain their role as participants and assured them that honest elaboration of their real situations would not cause any detriment to them. The focus of this study was on pregnant women technology adoption behaviours towards the usage of mobile health applications, which does not require probing on matters of medical nature.

## 3.9    Evaluation of qualitative research

To assess the qualitative research trustworthiness, the researcher considered applied criteria to do the investigation to ensure the quality of generated data. Lincoln and Guba (1985) indicated that a research study's trustworthiness is vital to evaluate its worth.

Therefore, this study evaluated according to the four criteria posited by Lincoln and Guba (1985):

- The credibility is similar to internal validation in quantitative approaches, which is confidence in the findings' truth.
- Transferability is applied by showing that findings are applicable in other contexts. To ensure the study's transferability, thick description and purposive sampling will facilitate the transferability of the inquiry.
- Dependability is applied by showing that the findings are consistent and can repeat. It was applied by establishing an audit trail by cross-checking the raw data interviews, observation notes, documents, and records collected.
- Conformability refers to the extent to which respondents' findings and researcher bias, motivation, or interest. The trustworthiness of findings will be visible through the audit trial will offer visible evidence.

### 3.9.1   Research credibility

In this study, the researcher applied credibility checks by adopting two credibility strategies: prolonged engagement and persistent observation (Sheldon, Lincoln & Guba, 2006). The prolonged engagement strategy aimed to conduct long-lasting interviews to create direct contact with pregnant women (study participants), which led to mutual trust. It was enhanced

by encouraging pregnant women to support their statements with examples, which led to follow-up questions that generated in-depth information. Furthermore, the ongoing observation strategy ensured the data credibility by developing thematic codes of the generated data; the concepts and core categories helped assess the data characteristics (Dimla, Wood & Parkinson, 2020).

### 3.9.2 *Research transferability*

To ensure the transferability of this study, the findings provide thick description of pregnant women's perspectives, thoughts, and understanding of mobile health applications and also provide a detailed description of their experiences with technology to make the findings meaningful to the reader and enable assessment of whether these findings can be transferred to similar studies.

### 3.9.3 *Research dependability*

Data stability can determine the dependability criterion over time. In this study, dependability was applied by using an audit trail outlining all the steps taken from the data collection to presenting the findings that emerged after the data analysis. Such as the raw data interviews, observation notes, documents, and records collected.

### 3.9.4 *Research confirmability*

Confirmability was applied in this study by providing the complete set of notes that explains the reflective thoughts, sampling, research materials adopted, and information regarding data management. In order to ensure the transparency of the study path. Indeed, applying these criteria was essential to ensure this qualitative study's reliability and examine trustworthiness.

### 3.10 Chapter Summary

This chapter describes this research's methodology and design. The study is qualitative in nature. It was chosen because it is considered the comprehensive method that produces rich primary data for this study. The research is based on a case study design that offers a flexible strategy to explore real-life phenomena. Bourbonnais et al. (2020) remark that a survey on users' perceptions will always be exploratory. The explorative nature allowed for in-depth interviews with pregnant women at Dream maternity hospital, where the study was conducted in Khartoum. Furthermore, the interview questions were designed into five sections; each section contained questions that captured pregnant women's information and aligned with the UTAUT model constructs as the framework for this study. The Unified-theory of Acceptance and Use of Technology (UTAUT) is a comprehensive model that combines the other models

presented above. Dwivedi et al. (2019) note that UTAUT is the most up-to-date model that explains attitudes towards technology acceptance and use.

The researcher conducted one-to-one interviews with pregnant women as the targeted population for this study. The data analysis in this study was content analysis as it is considered a practical method applicable to numerous disciplines; it provides clarity and meaning to raw texts (Liu et al., 2019). An inductive approach was taken to code text into categories that make meaningful themes. Atlas.Ti software was used to analyse interview transcripts into categories and make findings.

The next chapter is the findings and discussion chapter, which will present the study's findings and a discussion on the analysis, including an overview of the analysis outcomes and results.

# Chapter 4: Research findings and discussion

## 4.1    Introduction

The literature review examined previous studies on the adoption and usage of technology supporting maternal healthcare. Chapter 3 discussed the research methods followed in this study and introduced the plans, processes, design, and instrument development that guided the research. This chapter presents the research findings derived from the transcripts of the interviews. The transcripts of the pregnant women at the Dream maternity hospital in Khartoum city reflect their opinions and perspectives on mobile health (m-health) applications adoption and usage. The results presented in this chapter comprise an interpretation of the codes, themes, and associated networks, which are informed by the conceptual dimensions of the Unified-theory of Acceptance and Use of Technology (UTAUT).

The chapter commences by presenting the demographics of the interviewees. The second section presents the thematic outcomes, categories, and concepts derived from the qualitative data analysis.  The last section of this chapter concludes with a discussion of the findings presented in relation to the research question: *What factors affect pregnant women's perceptions of adopting maternal health-related mobile applications in Sudan*?

## 4.2    Demographics of participants

The table below (Table 2) presents an overview of this study participants' demographic data. The demographic profiles reported the research participants' age, education level, and marital status. In addition, the demographic section included questions on their experience with mobile phone usage, voluntariness on use and their awareness level of m-health applications.

**Table 2:  Demographics of participants**

|  |  | Frequency | Percentage |
|---|---|---|---|
| Age | 18-22 | 1 | 6% |
|  | 23-27 | 5 | 31% |
|  | 28-32 | 6 | 38% |
|  | 33-37 | 4 | 25% |
|  | Total | 16 | 100% |
| Level of Education | Primary School | 2 | 13% |
|  | High School | 2 | 12% |
|  | Graduate | 12 | 75% |

|  |  | Frequency | Percentage |
|---|---|---|---|
|  | Total | 16 | 100% |
| Marital Status | Married | 16 | 100% |
|  | Total | 16 | 100% |
| Do you own a mobile phone? | Yes | 16 | 100% |
|  | No | 0 | 0 |
|  | Total | 16 | 100% |
| How long have you been using a mobile phone? | More than 10 Years | 9 | 56% |
|  | 5 to 9 years | 5 | 31% |
|  | Less than 5 years | 2 | 13% |
|  | Total | 16 | 100% |
| How often do you use your mobile phone? | I use my phone all the time | 6 | 37% |
|  | Limited use | 10 | 63% |
|  | Total | 16 | 100% |
| Have you heard about m-health applications before? | Yes | 10 | 63% |
|  | Never Heard of it | 6 | 37% |
|  | Total | 16 | 100% |
| If yes, what do you know about the application | Track and Monitor Pregnancy | 5 | 50% |
|  | Health Education Tool | 3 | 30% |
|  | Calculate Birth Due Date | 2 | 20% |
|  | Total | 10 | 100% |

The study participants were sixteen pregnant women who reside in urban and rural areas. The majority of the participants are between 28-32 (38%), while 31% are aged between 23-27. In addition, 25% are aged between 33-37 years, and the minority (6%) are between 18-22 years old. The data shows that most participants residing in Khartoum suburbs are between 18 and 37 years old.

75% of the respondents' highest educational level is graduate level, while 13% of the participant's highest educational level is high school, and 12% have primary school as their highest level of education. This indicates that the majority of the sample (75%) are educated women with bachelor's degrees.

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All participants confirmed that they own mobile phones, while 56% have experience using mobile phones for more than ten years. 31% responded that their expertise in mobile phone usage does not exceed ten years, while 13% of participants stated that they had used mobile phones for less than five years. This finding highlight that although a majority of the sample have experience in mobile phone usage, 63% reported that they rarely use their phones. Furthermore, it was found that when the participants use a mobile phone, they only make calls, even though they have smartphones. On the contrary, 37% use their mobile phones frequently for different purposes, such as making phone calls, using social media and accessing the internet to search for information.

63% of the participants revealed that they are familiar with mobile health (m-health) applications for pregnancy. The data shows that they are familiar with the various functions of pregnancy applications, such as monitoring and tracking pregnancy, health education, and calculating birth due dates. In addition, 37% confirmed that they were unaware and had never heard of m-health applications for pregnancy tracking and management.

## 4.3 Research Findings

This section presents the research findings in response to the research question that explores the factors that affect the adoption and usage of maternal health-related mobile applications among pregnant women in Sudan.

The findings are presented according to each dimension per the theoretical research model: the Unified-theory of Acceptance and Use of Technology (UTAUT). The following sections will discuss each dimension based on the research model, starting with the first theme in the UTAUT: performance expectancy.

### 4.3.1 *Performance expectancy*

As discussed in detail in section 2.9 above, performance expectancy refers to the extent a person believes the use of the system will help them in attaining gains (Venkatesh et al, 2003). In this study, performance expectancy refers to the perception of pregnant women of the benefits they expect in support of attaining good maternal healthcare when using the m-health application.

The analysis outcome resulted in three findings demonstrating the nature of the benefits that pregnant women expect when they utilise m-health applications. The findings are summarised in the below table.

**Table 3: Summary of findings of Performance expectancy theme**

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| Theme | Category | A concept derived from the qualitative analysis |
|---|---|---|
| **Performance Expectancy** | **Mobile as a tool for <u>self-education</u> on general health** | <ul><li>Symptoms Information Tool</li><li>Drug safety Information Tool</li></ul> |
| | **Reduced anxiety (Improved confidence) and a sense of self-empowerment** | <ul><li>Mental Healthcare Improvement</li><li>Improved childbirth preparedness</li><li>Improved understanding of danger signs</li></ul> |
| | **Tools for supporting pregnancy: Being in control** | <ul><li>Monitor pregnancy stages</li><li>Improved nutrition Practices</li></ul> |

The table above (Table 3) summarised the performance expectancy theme based on the Unified-theory of Acceptance and Use of Technology. The following section discusses each theme, category and concept derived from the qualitative data analysis.

### 4.3.1.1  Mobile as a toll for self-education on general health

From a Performance Expectancy perspective, the first finding concerns the expectation that if the respondents were to adopt and use a mobile application, the m-health application must have the functionality and tools which allow respondents to educate themselves on general health. The data reveals that pregnant women are also concerned about their general health and avoiding complications that may endanger the mother's and infant's health. Moreover, pregnant women expect to receive benefits from an m-health tool that would enable better knowledge and empowerment in managing the pregnancy phase. Therefore, this was an essential element of performance expectancy among respondents.

It was found that pregnant women utilise mobile phone devices as a tool to access the internet to acquire pregnancy-related information. Furthermore, the internet greatly influences pregnant women since it provides information to help with self-management. Pregnant women considered retrieving information online would enhance low health literacy through education on pregnancy-specific understanding and information-seeking capacities that may assist throughout the pregnancy. The participants stated that they benefit from using m-health applications as they access them to search for health-related information, such as pregnancy symptoms, as the below responses show:

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*"When I feel sick, I google the symptoms to find health information to understand more about my symptoms" (Respondent 4, 34-year-old)* and

*"Last week, I felt bitter in my tongue. I used my mobile phone to search for symptoms and try to understand what caused bitterness; it made me uncomfortable; I googled it and reached all the information that I needed to know" (Respondent 2, 32-year-old).*

This study found that in low resources settings like Sudan, m-health applications for pregnant women could provide a communication tool to seek maternal healthcare information. In addition, information sources can be limited to rural areas, which motivates pregnant women to use m-health as an alternative source of information to educate them to be empowered and manage their health.

A similar study explained that pregnant women in low-income countries utilise m-health applications to learn about sickness symptoms and complications. Also, it was pointed out that self-education empowers pregnant women to have better health management during pregnancy (Leziak et al., 2021).

Another benefit area concerned with drug safety during pregnancy is understanding the side effects of medication concerning pregnancy development. Respondents use m-health applications to seek information on medication safety, understand the risks associated with medication usage on unborn child development, and avoid pregnancy complications. The evidence is in the following excerpts:

*"I use my phone to search for health information related to pregnancy, medication usage and side effects" (Respondent 9,23 Years old)* and

*"Sometimes I get scared to use a medication without its effect during pregnancy, I use my mobile phone to search for symptoms and medication side effects" (Respondent 3,35 Years old).*

As mentioned above, one of the respondents mentioned that they obtained health information about a specific drug by using a mobile device to search the internet for the side effects related to the medication. Furthermore, participants recognised that m-health systems could support them during pregnancy by using the internet to obtain information about drug safety for pregnant women. In addition, respondents tried to use a mobile device to access the internet

for health-related information. They reported this function as a service that offers easy access to healthcare.

Similarly, Dathe and Schaefer (2019) highlighted that pregnant women associate the use of drugs with a high-risk situation that can lead to the termination of the pregnancy. Therefore, one of the priorities for expectant mothers is to acquire accurate on the drug to ensure safety.

### 4.3.1.2 Reduced anxiety (Improved confidence) and a sense of self-empowerment

The next aspect of performance expectancy amongst respondents concerns using m-health applications to reduce anxiety in coping with childbirth. To demonstrate, pregnant women undergo physical and mental changes that affect their well-being. Furthermore, literature has proven that pregnant women experience anxiety twice as much as the general population (Sakamoto et al., 2022). Approximately 30% of pregnant women experience stress, anxiety and depression symptoms during pregnancy (Dathe & Schaefer, 2019). Even though mental changes are regular for expectant mothers, they can lead to conditions such as anxiety, depression and stress during pregnancy and childbirth preparedness.

The data shows that pregnant women are vulnerable to psychophysical health problems such as anxiety, depression and stress throughout their pregnancy as they need to learn more about pregnancy and childbirth. The data indicate that pregnant women use m-health tools to deal with uncertainty and anxiety during pregnancy, which leads to better mental health and higher self-confidence.

Moreover, pregnant women stated that m-health applications' features are beneficial in supporting mental health by providing a source of information to search and learn which relief the associated symptoms of anxiety and stress during pregnancy.

The following excerpts demonstrate this point:

*"I search for everything I need to know because I am always concerned about the little details because it is my first pregnancy" (Respondent 7, 24 Years old)* and

*"It can help me with the anxiety and uncertainty that comes with the pregnancy journey to learn more information on maternity" (Respondent 2, 32 Years old).*

From the above responses, pregnant women experience anxiety, especially in the first pregnancy, accompanied by emotional changes. Moreover, they are interested in utilising m-health technologies to help them manage their maternal health and access pregnancy-related information when needed. For example, it was found that pregnant women in this study prefer using m-health to access health information and overcome the challenge of geographic distance from their areas to the nearest clinic, which motivates them to engage with technology as a source of pregnancy and birth-related information. Therefore, pregnant women's engagement with m-health technologies leads to enhance confidence and empowers women to self-manage and have control during pregnancy. In addition, pregnant women revealed that they had recognised the importance of being self-educated on pregnancy, providing them with self-empowerment during and into childbirth.

Likewise, Moraes Carrilho et al. (2019) highlighted that although pregnancy is a natural life phase in women's lives, it can be accompanied by anxiety, which can lead pregnant women to use the internet as a source of information to help them deal with doubts and stress.

Empowering women through mobile health applications for self-management also supports their self-confidence. Another area of empowerment for pregnant women is birth preparedness which can include improving knowledge of the danger signs during pregnancy to avoid complications. The World Health Organization (WHO, 2018) recommends that every pregnant woman have a birth plan as a part of the prenatal plan. It is a plan that empowers women and leads their maternal health during pregnancy and childbirth preparedness. It was identified that pregnant women feel motivated to use m-health applications to access health information that prepare them as mothers for childbirth, including understanding symptoms and awareness of the dangers of pregnancy. Following are examples of responses that explain the latter:

*"The application gives me access to information that makes me understand the symptoms that I feel and recognise if its the danger signs or normal pregnancy symptoms" (Respondent 10, 28 years old)* and

*"Honestly, I do not know the warning signs, and I am entirely dependent on the doctor. However, now that you have shown me the application, I am impressed by the quick access to information pregnant women would need to know. For example, I used to have severe headaches during my first two weeks, and I didn't realise that it" (Respondent 9,23 years old).*

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Similarly to what was found above, the literature indicates that pregnant women are interested in using the m-health application to access the proposed birth plan, including childbirth preparations, identification of danger signs, and pregnancy stages (Moraes Carrilho et al., 2019).

### 4.3.1.3 Tools for supporting pregnancy: Being in control

Another aspect of the performance expectancy of pregnant women is the usage of m-health applications as tools for supporting pregnancy. The data indicate that pregnant women care about their well-being and prioritise monitoring their health throughout pregnancy. Furthermore, using m-health applications positively impacts the overall enhancement of self-care in pregnant women's healthcare. Therefore, it gives them a sense of self-empowerment to support managing their health, accessing maternal healthcare services, and promoting a healthy lifestyle during and after pregnancy.

In this study, pregnant women expect the features of m-health to support them throughout the pregnancy. Moreover, participants highlighted the pregnancy tracker feature as the most beneficial feature to use on the m-health application. This feature empowers them by posting daily articles related to their pregnancy on the application timeline, motivating them to encourage self-exploration and ask questions to increase their knowledge of maternal healthcare, which gives pregnant women a sense of comfort and relaxation that positively impacts the overall enhancement of self-care in pregnant women's healthcare.

For example the participants expressed the following:

*"Tracking my pregnancy will be an excellent benefit for me because I struggle to attend my appointment at the clinic; it is very far from where I live, and the doctor does not give me much information" (Respondent 2, 32 years old) and*

*"The most beneficial feature is that the application provides weekly-based information. Depending on my pregnancy development, I think it will support having available information. I would feel comfortable and relaxed" (Respondent 8, 37 years old).*

In a similar study, Li et al. (2021) found that m-health applications support pregnant women by motivating them to set health-related goals, follow them to focus on their well-being, and monitor their eating, sleep, exercise, and weight daily.

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Nutrition habits during pregnancy are essential for a baby's growth and development; however, poor diet quality affects low-income countries, limited access to food, and insufficient knowledge of the primary nutrients a pregnant woman needs. According to the data, pregnant women utilise m-health as a tool that provides pregnancy-supporting features. The data shows that pregnant women benefit from utilising m-health as a tool that reminds them to take supplements and works as a source of information to seek nutrition and pregnancy-related knowledge that a pregnant woman requires essentially for a healthy pregnancy development.

Examples of responses that demonstrate the latter are:

*"The most beneficial feature to me is the reminder to take my vitamins and the health education part about how this particular vitamin can benefit my baby, especially since I do not take milk. My doctor told me to take calcium supplements. I believe using such applications will help educate us the rural women "(Respondent 1, 29 years old) and*

*"This is my first pregnancy, and I think It's amazing how this application can educate me on what my body needs, such as iron and explain why I need it and how it would benefit my baby" (Respondent 16, 26 years old).*

There was a common understanding of the perceived utility of m-health applications among respondents. Likewise, Saronga et al. (2019) highlighted that in low and lower-middle-income countries, mobile health (m-health) initiatives proved to enhance pregnant women's adherence to taking vitamin supplementation during pregnancy.

In the performance expectancy theme, the study identified three main categories. The first is mobile as a tool for self-education on general health. In this category, participants identified two primary benefits of m-health usage: a symptom information tool, where they can search for information related to their symptoms and a drug safety information tool during pregnancy. These benefits positively influenced pregnant women's perception and intentions towards adopting m-health applications. The second category was reduced anxiety (improved confidence) and a sense of self-empowerment. The participants mentioned improved mental health, child preparedness, and understanding of pregnancy-related danger signs. These were direct positive influences of m-health adoption. The third and last category of theme one was tools for supporting pregnancy: Being in control of their health, which included monitoring and tracking pregnancy stages and improved nutritional practices. The feature of monitoring

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and tracking healthcare was the most beneficial to participants, particularly since health during pregnancy is a priority.

### *4.3.2 Effort Expectancy*

Effort expectancy is discussed explicitly in section 2.9 and was defined as the "degree of ease associated with the use of the system" (2003:450).

In this study, the effort expectancy was assessed by examining pregnant women's expectations concerning the ease of use of mobile health applications to access maternal healthcare. The analysis outcome resulted in two findings demonstrating pregnant women's expectations regarding the ease of use of mobile health applications. The findings concerning effort expectancy are summarised in the below table.

**Table 4: Summary of findings of effort expectancy theme**

| Theme | Category | Concepts derived from the qualitative analysis |
|---|---|---|
| **Effort Expectancy** | **Technology Familiarity** | • Ease of Use<br>• Application Clarity |
| | **Perceived value of utilisation** | • Ease of Access<br>• User Interface Design |

These are discussed in the following subsections:

### 4.3.2.1  Technology Familiarity

A category has emerged in effort expectancy theme analysis: technology familiarity. Being familiar with today's technology advancements requires engagement with mobile applications to have experience using technologies to perform different activities. M-health technologies are expected to enhance women's access to healthcare and encourage self-care and maternal knowledge. However, a certain level of technology familiarity can impact pregnant women's perspectives towards accepting and using m-health applications to access maternal healthcare services.

Furthermore, in this study, participants were asked about their experience using mobile phone applications to explore the effect of the usability of m-health to find health information that allows them to monitor and assess them during pregnancy. The data identified that pregnant women are willing to use m-health applications if they have experience with its usage, making it less effort for them. Furthermore, respondents reported that they are exposed to social media

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applications as a communication tool and other applications for different activities. Therefore, this experience in using mobile applications would make it easy to use m-health applications.

The following are excerpts of the interviews which illustrate the latter:

*"I have little experience using mobile applications, like Whatsapp and Facebook and language learning applications to learn English, but It will help not to fear using the new application" (Respondent 16, 26 years old) and*

*"I think I will understand how the m-health application work since I have experience using other applications in general as I told you I use social media applications, Facebook and WhatsApp, for communication with family and friends and Facebook. And I use uber and games applications" (Respondent 15,28 years old).*

The evidence in the literature (Ayyoubzadeh et al., 2022; Javanmardi et al., 2018) proved that after using internet search engines and smartphone applications, pregnant women tend to have more confidence in using m-health applications as an information source to support different features such as appointment reminders and seeking information about body changes and nutrition needs during pregnancy (Shroder et al., 2018). Likewise, Alamer and Al-Edreese, (2021) revealed that using social media applications positively affects pregnant women's behaviour towards using technology to search for health information related to their pregnancy and childbirth.

On the contrary, a few participants indicated that they have limited experience, such as using google to search for pregnancy-related information. However, they stated they are afraid of utilising technology and will likely prefer not to use m-health applications. The following excerpts illustrates:

*"No one around me uses mobile applications, so I am not aware of them. I only use search engines like google to find information but rarely" (Respondent 2, 32 years old) and*

*"I only have the Facebook application on my phone, but as I said, I log in every once in a while, and I think it will be easy, but I am not willing to use it. I am afraid of technology, it is not something that I am used to, and I do not know much about it" (Respondent 1, 29 years old).*

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The data indicates that application clarity contributes to pregnant women's motivation and increases their willingness to use different applications to move towards digital daily life services accessing services. Participants mentioned their fear of technology which they overcame by using popular mobile applications such as social media, where they can communicate with family and friends and find exciting topics, mobile banking, and language learning applications. From their perspectives, those applications are easy to learn and use. In addition, the data illustrates that pregnant women utilise m-health as a platform to seek maternal healthcare information, connecting with other pregnant women to share and learn from their experiences which can significantly contribute to their maternal knowledge. Another point is the application clarity on the use and registration step that might be difficult for pregnant women and mothers in the Sudan context. Examples of respondents that explain the latter are:

*"Well, I am not confident in using unfamiliar mobile applications because I still fear technology. I am more comfortable with the popular applications that everyone uses. Other applications might be difficult to use, and I do not have good technology experience" (Respondent 7, 24 years old) and*

*"Now I am pregnant with my second baby, so I think I have more experience than before, but I had to join maternity groups on Facebook during my first pregnancy. They recommended an m-health application that most of them use. The application has a chat feature where mothers can connect. The application helped me help me understand how to calculate my birth due date and track my pregnancy. I downloaded the application and created an account; it was easy and simple. The mothers' groups on Facebook helped to understand how the application features work. This experience benefited me greatly; first, I enhanced my technology skills, and I learned about maternity and the pregnancy journey" (Respondent 15, 28 years old).*

### 4.3.2.2 Perceived value of utilisation

The second aspect of the effort expectancy theme is the perceived value of using m-health applications that encourages pregnant women to adopt new technology. In other words, the lower the effort required to use technology, the higher the perceived performance because easier-to-use technologies facilitate fulfilling the user's goals (Venkatesh, 2000). Also, Palos-

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Sanchez et al. (2019) demonstrated that perceived usefulness significantly affects users' intentions toward utilising m-health technologies.

Furthermore, women who experienced pregnancy use mobile health applications to seek health information regarding their pregnancy and infant's health. Pregnant women still need more knowledge about pregnancy to feel more comfortable utilising the internet as a source of information before or after a prenatal check-up. It was found that regardless of age, participants use m-health applications to become knowledgeable on maternal healthcare-related information. Moreover, participants' utilisation of online health as a source of information is a form of acceptance of technology adoption to find answers to their health questions and manage their health.

The data demonstrate that participants expressed their intentions towards accepting, learning and using the internet as a source of maternal health-related information. They are willing to make an effort and learn to utilise it as long as they can access the health information they require. The subsequent quotations describe an example of the responses:

*"I think if I can not reach my doctor for any reason and need to know information about my pregnancy, I will use the application or let me say the application will be beneficial to me. Because I know I will be seeking health information, I am not sure if it will be easy to find answers, but I will ask someone to help me train me to use it" (Respondent 2, 32 years old)*

*and*

*"It can help me access health information if I feel unfamiliar symptoms. For example, my doctor is not available if my baby stops moving if I do not feel the kicks. I think I will be so scared, and I would want to know if it is normal or not. From what you explained to me, the applications can monitor my pregnancy very well. In this case, I might be in a rush to understand what is happening to my baby, and I would want to know more about it" (Respondent 4, 34 years old).*

In a similar study, Maslen and Lupton (2018) revealed that pregnant women easily access the internet to find health information related to their pregnancy, fetal development, and lifestyle.

The user interface design plays a critical role in users' behavioural intentions towards adopting m-health technologies. However, m-health technologies' usage is surrounded by the ease of

usability barriers that affect user adoption and usability of users, as the representations and functionality of the system. As a result, the participants expressed frustration regarding the usage, starting with the fear of technology and the difficulties they face when using m-health. In this study, when participants try to use m-health technologies and face usage difficulties, it creates uncomfortable feelings that negatively influence their perceptions of technology adoption and usage. For example: creating an account and understanding and utilising the application's functions. In other words, usability difficulties affect their intentions to accept using health technology to improve maternal healthcare services.

It was found that the majority of the participants in this study do not use m-health applications due to preferring the traditional way (e.g., face-to-face with health care provider) of seeking health-related information. Another point was that m-health applications are difficult to use as they lack knowledge of mobile applications. The following excerpts demonstrate examples of the responses:

> *"I am not sure if I can put my trust in a mobile application to guide me through my pregnancy. Because I fear technology because I don't have experience and I prefer going to the doctor as the main source of my health information. I tried before to use similar applications, and I was discouraged by the difficulties to create an account on the application, so I quit immediately and didn't try again" (Respondent 14, 27 years old) and*

> *"It is complicated to understand how to use this application, and I think it will take much effort and time for me to learn to use it. I don't know how to go to the home page, there are no clear instructions to follow to access the information I need, and if the language is not Arabic, I will not be able to understand a word" (Respondent 1, 29 years old).*

Similarly, the literature discussed that the application design significantly contributes to user satisfaction and increases adoption rates (Vaghefi & Tulu, 2019). Also, m-health is likely adopted by users when they believe the technology is simple, convenient and requires minimum effort in usage (Farahani et al., 2018). Likewise, this study found that participants prefer an easy-to-use application, which also gives them a strong perception of accessing health services and a pleasant user interface.

### 4.3.3 *Social Influence*

Social influence is "the degree to which an individual perceives that it is important that others believe he or she should use the new system" (2003:451), this was discussed above in chapter 2, section 2.9 The study's social influence theme examines the influence of relatives and friends on pregnant women's behaviours towards accepting and using m-health applications. The concepts that emerged from the analysis are summarised in the following table.

**Table 5: Summary of social influence theme**

| Theme | Category | A concept derived from the qualitative analysis |
|---|---|---|
| Social Influence | Social support influence | • Friends use m-health<br>• Mothers support |
| | Family and friends encourage adopting m-health | • Family and friends' motivation<br>• following friends and family choices |

#### 4.3.3.1 Social support influence

In analysing this theme, the researcher identified a notion of the social influence on technology acceptance and utilisation among participants' responses. Social relationships influence pregnant women's m-health technology expectations. Moreover, the social relationships are linked to the participant's behavioural intentions that impact their technology use behaviour. Zhang and Zaman (2019) recognised that social influence shapes the perceived value that impacts users' decisions to accept technology.

The data explains the influence of social relationships on pregnant women's interaction with m-health applications and how social relationships can influence individuals' attitudes, intentions, and perceptions of health technology. Moreover, it was found that pregnant women's friends and family utilise m-health applications to access maternal health care, such as monitoring pregnancy stages, as evidenced in the following excerpts:

*"Yes, my sister-in-law is using m-health applications during her pregnancy, and she told me about how the technology supports her and how it works" (Respondent 3, 35 years old) and*

*"Yes, as I mentioned before, the pregnant women Facebook groups' friends use such applications, but most of them use it for pregnancy counter and to calculate the birth due date" (Respondent 15, 28 Years old).*

In a similar study, Nunes, Limpo and Castro (2019) noted that social influence has a strong effect on women on whether they follow their social circle choices and accept technology or has no direct impact on their decisions.

Another concept of the social support category is the mothers' support. It was found that participants communicate with other pregnant women and mothers at doctor appointments or social occasions. The participants indicated that they discuss maternity-related topics such as fetal growth, healthy diets and doctors' instructions. In addition, m-health applications are discussed as a topic among women as a tool that supports pregnancy and improves access to maternal healthcare services. Furthermore, mothers' networking improves knowledge and awareness and positively influences pregnant women's intentions towards utilising m-health applications. Therefore, the participants likely prefer to receive support for m-health applications from mothers and pregnant women. This is summarised in the quotations below:

*"At the clinic, when I go for my appointment, I usually meet and chat with pregnant women and mothers there, I made friends there and recently one of them told me about m-health applications , honestly after she showed me the application I wasn't excited to use it I felt its difficult, however I was influenced by her experience of using the application throughout her pregnancy, then I was convinced to use such applications" (Respondent 9,23 years old).* and

*"I believe recommendations from a pregnant woman would really make me change my mind on the acceptance of m-health applications, as we discuss and share similar topic related to maternity on different platforms, social media and face to face at any social occasion"*
*(Respondent 11, 18 years old).*

In this study, pregnant women's friends and family, as well as support from mother-to-mother social connections, significantly influence their intentions to adopt and use technology. At the same time, it also informs them about using m-health as a pregnancy support tool. Similarly, research from the literature indicates that in rural areas, mother-to-mother networking has effectively increased the acceptability of m-health tools among moms (Choudhury & Choudhury, 2022).

### 4.3.3.2   Family and friends encourage adopting m-health

The following section discusses the second category of this theme: family and friends encourage adopting m-health. Furthermore, social connections within each person's social network, such as family and friends, play an important role, especially during a critical life stage such as pregnancy. The first that emerged in this category is the motivation of family and

friends. The data indicate that participants receive support from their friends and family members about the usage of m-health applications. Therefore, social interactions allow the sharing of m-health knowledge, which attracts users to interact with technology. This influences their behaviour, yet when they attempt to utilise it, they fail due to a lack of technological abilities. For example, participants stated:

*"yes, I will be encouraged to use it if someone I know who is also pregnant is using it. Maybe if I have a pregnant friend, she can also teach me how to use it, and then I will try to learn more from her and use it to support my health during pregnancy" (Respondent 1, 29 years old).*

*and*

*"yes, of course, I would be encouraged to use it if my friends recommend it to me, and I think it will support me during my pregnancy. I trust my friends and their choices. I believe I would be curious to explore the features" (Respondent 2, 32 years old).*

Likewise, AlJaberi (2018) noted that pregnant women networking with their social circle such as family and friends helps them as a group of pregnant women, which significantly influences them digitally connecting to platforms that strengthen their capacities to acquire health-related information.

Another notion is that pregnant women follow friends and family's choices regarding m-health applications. Moreover, few participants indicated that social networks are likely negatively or positively impact their attitudes towards m-health adoption and usage. The following responses emphasise respondents' positive intentions, the significant influence of social relationships, and their acceptance of m-health applications on the participants to obtain access and improve their self-management to their well-being. The below are excerpts of the interviews:

*"my sister told me that she is using this technology and that it supported her a lot during her pregnancy. I tried to learn and use it after my cousin recommended it to me and told her experience with the application during and after her pregnancy. I tried to use it to track my pregnancy, but I failed because it was too difficult for me" (Respondent 10, 28 years old) and*

*"yes, of course, I will use it if my friends recommend it to me, and I think it will support me during my pregnancy because I trust my friends and their choices. But when I tried to use it, I was not encouraged because It is complicated. I downloaded the application on my Mobile, and I was excited to use it, but I could not create an account. Dealing with such an application was challenging and complicated, and I felt I do not need it"*
*(Respondent 3, 35 years old).*

Cobelli and Chiarini (2020) highlighted the impact of that social relationship on an individual's willingness to adopt new technology tools, leading them to value the opinions and perceptions of their social network.

Nevertheless, the majority of participants expressed that their intentions are not associated with their social relationship choices, and it has no effect on their preferences. In addition, their choices, decisions, and behaviour towards adopting technology are determined by the benefits they will receive from the application and its value concerning maternal healthcare services. The following interview excerpts illustrate the point:

*"No, I will not use it just because someone I know uses these applications; I will use them when I know its benefits and features and decide if it supports me, then I can use the technology"* *(Respondent 6, 32 years old)*
*and*
*"Yes, my friends use it, and they told me about it and explained everything about the application to me. But honestly, I did not think about using it because I regularly visit the doctor and get all the information I need"*
*(Respondent 8, 37 years old).*

In summary, social influence is the third theme and revealed that social support has a major influence, the use of m-health by friends and friends or family influencing the choice of the m-health application selection. The use of m-health applications by friends and family influenced pregnant women's choice of application adoption.

Family and friends encourage adopting m-health was the second category in the theme where friends and family motivate the participants to use m-health applications, and they also follow the recommendations of their friends and family.

To conclude, the social influence theme revealed that social support has a major influence, the use of m-health by friends and friends or family influencing the choice of the m-health application selection. The use of m-health applications by friends and family influenced pregnant women's choice of application adoption.

Family and friends encourage adopting m-health was the second category in the theme where friends and family motivate the participants to use m-health applications, and they also follow the recommendations of their friends and family.

### *4.3.4 Facilitating conditions*

As discussed in section 2.9 abover, facilitating conditions, are "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). In this study, facilitating condition's theme examined pregnant women's behaviour to understand the existing facilitating requirements associated with pregnant women's behavioural intentions towards m-health technology usage concerning access to maternal healthcare services. In addition, facilitating conditions that could be essential predictors of m-health applications adoption are digital literacy, affordability, and confidentiality facilitators. The following table summarises the concepts of this theme.

**Table 6: Summary of findings of facilitating condition's theme**

| Theme | Category | A concept derived from the qualitative analysis |
|---|---|---|
| **Facilitating conditions** | **Facilitators of m-health utilisation** | • Language barriers <br> • unstable electricity <br> • Lack of knowledge |
| | **Impact of Affordability and confidentiality** | • Minimum cost <br> • privacy concerns |

### 4.3.4.1 Facilitators of m-health utilisation

With the availability of m-health applications, there is a potential for pregnant women to improve their access to maternal healthcare services. However, the challenge of individual technology adoption is significant. The extent to which pregnant women are willing to engage with m-health considering the discomfort they might feel for different reasons. Reasons include the cost of data services, poor internet connectivity and unstable electricity—lack of computer and intelligent phone skills, illiteracy, and unreliable m-health applications. Furthermore, the following section illustrates the facilitating conditions that emerged from the analysis of this theme that impeded m-health adoption.

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The data indicate that pregnant women consider the language a barrier, as they prefer the local language in Sudan as an option in the application. Furthermore, pregnant women expressed their interest in utilising m-health technologies. For example, participants revealed:

*"I would use it if there is a clear guide on the usage, and I would prefer if the application language is Arabic, it will make it very easy for me to use it"* (Respondent 3, 35 years old) and

*"I think it should be free services and promoted by the health ministry and supported by all kinds of phones. I am a little concerned about the language, and I think the application must be available in the Arabic language, with clear usage instructions"* (Respondent 5, 34 years old).

The second concept in relation to the category of facilitators of m-health utilisation is unstable electricity. Moreover, pregnant women expressed that unstable electricity is one of the challenges of utilising m-health applications, poor internet services, and low literacy levels among pregnant women. Participants revealed that stable electricity and adequate ability to use smartphones independently would be one of the factors that will facilitate the utilisation of mobile applications. In addition, the availability of these resources would facilitate usage and directly affect participant technology usage intentions. The following quotations are examples of the participants perspectives on this point:

*"I need a smartphone and electricity. Where I live, there is no electricity. I also need to be trained on how to use it"* (Respondent 1, 29 years old) and

*"I think I first need a smartphone, electricity, and more useful information. Maybe if someone volunteered to train me, I would be able to understand how it works and start using it"* (Respondent 13, 32 years old).

It was found that participants require more knowledge and skills to facilitate the use of m-health tools. Therefore, they mentioned that the knowledge gap could be bridged by receiving training to enhance their skills and be well-informed on m-health tools. It was noted that participants were willing to accept m-health if they raised their knowledge level on mobile application usage. Examples of the respondents opinions are:

*"I believe using mobile applications requires skills to understand and use the application right. I lack basic skills. And I would not say that I refuse to*

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*use this technology, but I need to work on my skills" (Respondent 3, 35*

*years old)* and

*"I think what helps using the application to monitor my pregnancy is if I*
*have adequate knowledge. I am always worried that I waste my time*
*understanding how an application works. Instead, I prefer that someone*
*can train me to save time and effort. This will encourage me to use the*
*application and improve my skills" (Respondent 10, 28 Years old).*

Similarly, literature evidence shows that in rural areas, pregnant women were introduced to m-health interventions through mobile devices, audio and videos that improved their knowledge of the e-services and motivated them to engage with technology to enhance their accessibility to maternal healthcare (Mbuthia, Reid & Fichardt 2019).

### 4.3.4.2  Impact of Affordability and Confidentiality

Mobile devices can offer a cost-effective source to access maternal healthcare services in the Sudan context. Furthermore, the utilisation of m-health applications can reduce in-person visits and transportation to travel to the clinic. However, the network coverage could be a barrier in some areas, in addition to the cost of internet data bundles. The following section will discuss the influence of the affordability of internet services and the confidentiality of private data on m-health applications from the participants' perspectivees.

In this study, it was found that most pregnant women are willing to buy data bundles to use m-health tools with to the cost impact on the decision to choose to use m-health to access maternal healthcare services that would likely support them during pregnancy. The following interview excerpts provides an example of the participants responses:

*"I believe that the cost of the internet will not affect my decision to use the*
*application If I want to use it will anyway if I know that the technology will*
*support me and provide me with good maternal education and*
*information" (Respondent 10, 23 years old).*

Likewise, a similar study by (Almegbel & Aloud, 2021) found that individuals weigh the benefits they receive from the new technology over the monetary cost. And the cost of utilising m-health technologies does not influence users' intentions towards adopting new technologies (Said, 2023).

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The second concept that was identified in this category is privacy concerns. While mobile applications have been available and accessible to improve healthcare; however, private data security is a concern to users. Furthermore, it was found that the majority of the participants have concerns regarding the privacy risk they have to take when using technology. As the application stores its sensitive data, the participants would not trust technology and are concerned about the security and confidentiality of their sensitive data. In addition, pregnant women stated that privacy concerns would negatively influence their intentions towards using m-health applications. The following are examples that demonstrate respondents point of view:

*"Yes, privacy will be an issue for me because I am not exposed to technology and phones. I do not trust technology because I heard that your personal information can be public, and everyone can see it" (Respondent 11, 18 years old)* and

*"It is risky to put my personal information on the application and expect it to be protected. How will I guarantee confidentiality and protection of my sensitive data stored on the application so yes, I believe privacy will affect my usage decision" (Respondent 14, 27 years old).*

Similarly, Dhagarra, Goswami and Kumar (2020) indicated that data security and privacy risks are associated with patients' negative attitudes and behaviour towards accepting new technology. On the other hand, few participants were confident that their data would be secure and that the technology was reliable. Furthermore, pregnant women indicated that data privacy and security had no direct impact on their intent to use m-health applications. For example, participants revealed the following:

*"To me, privacy is not a problem because I trust that the application will protect my data and focus on benefiting me more. But what will be a great obstacle is the language if the application is only in English, I cannot use it as I only speak and understand Arabic" (Respondent 13, 32 years old).* and

*"If the application stores my personal data safely. Because it is sensitive data, I will consider using it as I am concerned about its privacy. It matters. Privacy will not be an issue for me" (Respondent 12, 23 years old).*

### *4.3.5   Socio-cultural factors*

This section presents the findings that emerged from the analysis of the socio-cultural factors theme. Furthermore, this theme examined pregnant women's views from the perspective of gender differences in rural communities that gives women less access to technology. The table below summarises the concepts in analysing the socio-cultural factor's theme. In particular, the factors discuss the gender differences and cultural beliefs that influence m-health adoption among pregnant women in the Sudan context. The following table summarises the categories and concepts identified in this theme.

**Table 7: Summary of the socio-cultural factors theme**

| Theme | Category | A concept derived from the qualitative analysis |
|---|---|---|
| **Socio-cultural Factors** | **Understanding gender differences (women have less power to make decisions)** | <ul><li>Male decision-makers</li><li>permission to use m-health</li></ul> |
| | **Maternity practices follow Cultural beliefs (traditions restrict pregnant women's opportunities for improved maternal healthcare)** | <ul><li>Culture hinders m-health</li><li>Equal access</li></ul> |

### 4.3.5.1   Understanding gender differences

In developing countries, the traditions empower men with the ability to make decisions as men are seen as an influential member of the family, which give women less power to decide and engage in their gender gap is a genuine concern that influences the adoption and access of technologies. This was supported by the findings of Addotey-Delove et al (2020) that women face a 'gatekeeper effect' that requires them to seek permission from their parents, husbands, or partners to use a cellphone. In examining the gender differences among pregnant women in Sudan, participants indicated that their partners generally have the right to decide on their behalf. In addition, the participants elaborated that it is associated with their community culture that men have the power to make decisions. An example of the participant's responses is:

> *"Yes, my partner can decide for me he knows better, and our culture says I*
> *should follow my man.  Me and partner can make decisions together. In*
> *other words, he can decide for me if he knows better" (Respondent 15, 28*
> *years old).*

Another notion is the concept of partner permission to use an m-health application. Respondents explained that their partners control their decisions and limit their use of mobile

phones to the extent that gives women less power to decide and engage with technology. Respondents reported that partners have natural rights by the traditions to control their wife's technology usage, whereas women cannot claim their rights to adopt the technology. In addition, this gender gap brings pregnant women a sense of inequality. Men can control their decision-making ability and give women less access to online sources that could empower them. The following excerpts shows examples of the participants responses:

> *"I need his permission, and if he refused, I would not use it. I am afraid of technology, so I don't think I will use it. Cultural beliefs in my village effect using technology, especially for maternity; we believe it is private and only women should know the of pregnancy"* (Respondent 11, 18 years old) and

> *"I am forced by the traditions to take his permission because he controls how I use my phone; I will tell him first because this baby belongs to both of us, so yes, I will take his permission"* (Respondent 2, 32 years old).

### 4.3.5.2 Maternity practices follow Cultural beliefs (traditions restrict pregnant women's opportunities for improved maternal healthcare)

Another perspective on the theme of social-cultural factors is the maternity practices that follow the cultural beliefs which control pregnant women in Sudan. However, m-health technologies have advanced and penetrated the world. However, cultural beliefs in Sudan shape pregnant women's behaviour, which minimises their opportunities to be empowered through technology usage. Furthermore, in developing communities,' there are culture, language and social barriers among disadvantaged groups that influence their use of the available digital resources (Hughson et al., 2018).

The first concept is that culture hinders pregnant women's adoption of m-health applications. Moreover, it was found that cultural beliefs, such as using technology, could cause cancer and that maternity practices are known better by community elders limit pregnant women from using m-health applications. Hence, they follow their traditions and refuse the use of m-health interventions. For example, the participants expressed that:

> *"Our beliefs do forbid us from using technology, like the belief that says technology causes cancer. I believe it will be a barrier to use m-health interventions to access maternal services, which affects our knowledge*

*level of such applications and our ability to use it" (Respondent 2, 32 years old)* and

*"I think our culture does affect our technology usage, especially when it comes to maternity. We believe that our elders know better than the doctor. Otherwise, they wouldn't have given birth and raised generations without going to doctors "(Respondent 16, 26 years old).*

Another concept in this category is women's equal access to technology. This concept presented cultural beliefs regarding giving men rights and priorities over women. Furthermore, the participants in this study emphasised that technology accessibility should be equal for both men and women.

It was found that technology is more gender-biased, and men dominate all aspects of the community. Besides that, the interviewee elaborated that, according to cultural norms, women are expected to follow traditions while men are prioritised in the community. Following traditions put women under pressure since they are expected to devote their time to their husbands and children and not waste time on their phones, even if it is to use a mobile application which will help them during their pregnancy. Furthermore, the community highly values men over women, allowing men to spend more time using mobile applications and accessing technology. For example, men have always been served food first to get the best dishes at social events, whereas women have leftovers. As a result, participants stated that technology in Sudan is more biased against men as an outcome of culture and traditions. This was indicated in the following responses:

*"Yes, technology is more gender bias, discrimination is real in Sudan, beliefs such as men should eat before women who give them the right always to come first and use second in everything in this life" (Respondent 2, 32 years old)* and

*"In our communities, women are always forced to give their time to husband and children, where will I find a time to use my mobile phone for we live in an unequal community where everything is made for men" (Respondent 16, 26 years old).*

Likewise, what was found in this study is that women have unequal access to technology, such as the use of m-health applications, due to cultural restrictions and maternity practices that

follow the traditions. In addition, the evidence in the literature highlighted that women are subject to discrimination in technology diffusion (BenYishay et al., 2020).

As discussed above, the findings in the theme of socio-cultural factors reflect that male have the power to make decisions on the utilisation of m-health adoption, which gives their female partners less access to technology and limit their opportunities to access and use technology. In addition, it was found that cultural beliefs and traditional practices concerning maternity have a negative impact on pregnant women's perceptions of adopting m-health applications.

## 4.4  Chapter Summary

This chapter presented the findings derived from the interview transcripts designed based on the UTAUT model. The interviews with the pregnant women at the Dream maternity hospital in Khartoum city reflect their opinions and perspectives on m-health applications adoption and usage. Also, the results interpret the codes, themes, and networks created based on the Unified Theory of Acceptance and Use of Technology (UTAUT) model.

To answer the research question *"What factors affect pregnant women's perceptions of adopting maternal health-related mobile applications in Sudan?"* the researcher applied the Unified Theory of Acceptance and Use of Technology (UTAUT) constructs as a model to guide the study, in addition to theme that examined the socio-cultural factors in Sudan context. Finally, the researcher presented the findings based on the five themes, their categories and concepts derived from the qualitative analysis.

*The key findings revealed that privacy concerns and lack of trust negatively influence pregnant women's perceptions of using m-health applications. It was found that participants had low trust in technology and were also concerned about their data privacy. Besides the lack of smartphones and stable electricity, language barriers exist. Significantly, the socio-cultural factors negatively influence pregnant women's perceptions as they have less access to technology and maternity practices strongly following cultural beliefs. These factors impacted and influenced the adoption of m-health applications by pregnant women in Sudan.*

The final chapter will present a summary of the key findings of this research. In addition, chapter 5 will present the key factors that affect pregnant women's perceptions as well as highlight the research process, potential limitations, contributions of this research, and suggestions for further studies.

# Chapter 5: Conclusions and Recommendations

## 5.1    Introduction

This chapter concludes the study.  It begins by presenting a summary of the previous chapters, illustrating what has been done. The chapter provides a final response to the primary research question, further evaluates the achievement of the research objectives and makes final recommendations.

This study explored the perspectives of pregnant women towards adopting mobile technology to improve access to maternal healthcare services. The underlying objective of the research was to identify the factors which influenced women's usage decisions in the problem context. The study began by presenting a review of the extent literature on e-health and m-health adoption in health care. Then, the study examined pregnant women's attitudes towards adopting and using m-health technologies by conducting semi-structured interviews at Dream, a specialised maternity hospital in Khartoum city, Sudan. The investigation was informed by the UTAUT adoption model (Venkatesh et al., 2003) using a qualitative methodology and design that produced rich primary data for this study. This chapter discusses the limitations, future research recommendations, and study contributions.

## 5.2    Summary of research findings

Table 8 depicts the key findings related to the factors influencing the adoption of m-health applications among pregnant women in Sudan.

**Table 8: Summary of the research findings**

| Theme | Summary of findings |
|---|---|
| Performance expectancy | **Mobile as a tool for self-education on general health** identified two primary benefits of m-health usage. It is a symptom information tool, where they are able to search for information related to their symptoms and a drug safety information tool during pregnancy. These benefits positively influenced their perception and intentions towards adopting m-health applications. <br><br> **Reduced anxiety (Improved confidence) and a sense of self-empowerment** identified improved mental health, improved child preparedness and improved understanding of pregnancy-related danger signs. These were direct positive influences of m-health adoption. <br><br> **Tools for supporting pregnancy:  Being in control** identified Tools for supporting pregnancy: Being in control of their health, which included monitoring and tracking pregnancy stages and improved nutritional practices. The feature of monitoring and tracking healthcare was the most beneficial to participants, particularly since health during pregnancy is a priority. |

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| Theme | Summary of findings |
|---|---|
| Effort expectancy | **Technology familiarity** negatively influenced the participants, as they have concerns about ease of use and application clarity.<br><br>**The perceived value of utilisation** identified ease of access to health services and friendly user interface design as a positive influence that gives them a strong perceived in terms of accessing health services and pleasant user interface. |
| Social influence | **Social support** identified that the use of m-health by friends and friends or family influencing the choice of the m-health application has a positive influence on the participants' decision to use m-health applications to access maternal healthcare services.<br><br>**Family and friends encouraged adopting m-health** identified friends and family motivation as a positive influence on the participants to use m-health applications. They also followed the recommendations of their friends and family. |
| Facilitating conditions | **The facilitators of m-health utilisation** identified that language barriers, poor network coverage, and lack of adequate knowledge negatively influence pregnant women's perspectives towards adopting and using m-health in Sudan.<br><br>**The impact of affordability and confidentiality** identified the cost of internet and privacy concerns has a negative influence on the participants. |
| Additional findings: social-Cultural factors | **Understanding gender differences impact (women have less power to make decisions)** identified that males make decisions and have priority over females in their communities given by the culture. This has been found as a negative influence on adopting and using m-health by pregnant women in Sudan.<br><br>**Maternity practices follow cultural beliefs (traditions restrict pregnant women's opportunities for improved maternal healthcare)** identified that cultural beliefs and traditional practices in relation to maternity negatively influence pregnant women's perceptions towards adopting m-health applications. |

The above table summarises the findings based on the five themes, their categories and concepts derived from the qualitative analysis. In the Performance Expectancy theme, the study identified three main categories: mobile as a tool for self-education on general health, reduced anxiety (improved confidence) and a sense of self-empowerment and tools for supporting pregnancy: Being in control. The first category is mobile as a tool for self-education on general health. In this category, interviewees identified two primary benefits of m-health usage. First, it is a symptom information tool, where they are able to search for information related to their symptoms and a drug safety information tool during pregnancy. These benefits positively influenced their perception and intentions towards adopting m-health applications. The second category was reduced anxiety (improved confidence) and a sense of self-empowerment. The participants mentioned that improved mental health, improved child preparedness and understanding of pregnancy-related danger signs were positively influenced by m-health

adoption. The third and last category of theme one was tools for supporting pregnancy and controlling their health, which included monitoring and tracking pregnancy stages and improved nutritional practices. The feature of monitoring and tracking healthcare was the most beneficial to participants, particularly since health during pregnancy is a priority.

The second theme is effort expectancy and is related to technology familiarity, including ease of use and clarity with the m-health application. While the perceived value of utilisation includes ease of access to health services and friendly user interface design, participants prefer an easy-to-use application, which also gives them a strong perception of accessing health services and a pleasant user interface.

The social influence theme revealed that social support significantly influences pregnant women's intentions to use m-health applications. Furthermore, the data indicate that pregnant women accept m-health applications when they receive information from mothers or pregnant women. Besides that, pregnant women in the study tend to follow the recommendations of family members and friends regarding the use of m-health applications.

Facilitating Conditions is the fourth theme that highlighted two categories, the facilitators of m-health utilisation and the impact of affordability and confidentiality. The participants indicated that language was a strong barrier to adoption, poor network coverage, and lack of adequate knowledge negatively influenced the adoption of m-health. In the Sudanese context, the local language is Arabic; therefore, participants preferred the application to be Arabic to enable them to have better interaction and usability. Language is a crucial factor that strongly influences pregnant women's perceptions and intentions towards adopting mobile technology. Understanding gender differences impact (women have less power to make decisions) was identified as a category of the social-cultural factors. The findings revealed that males could make decisions on the utilisation of m-health adoption, which gives their female partners less access to technology and limits their opportunities to access and use technology.

Indeed, in Sudan, the traditions empower men with the ability to make decisions as men are seen as influential members of the family, which give women less power to decide and engage in their gender gap. This is a concern that influences the adoption and access to technologies.

Another category that emerged from the social-cultural theme is maternity practices follow cultural beliefs. This indicates that pregnant women have limited access to maternal healthcare services. Furthermore, it was found that cultural beliefs and traditional practices concerning maternity negatively influence pregnant women's perceptions of adopting m-health

applications. In Sudan's context, culture plays a role in maternity practices where the reference is the culture which contradicts adopting innovative solutions that provide different practices than the old traditional. This is a factor that limits pregnant women from adopting and using technology.

## 5.3    Summary of Key Adoption Factors

Based on the findings of this study, the figure below illustrates the factors that influence the adoption of m-health technologies among pregnant women in Sudan.
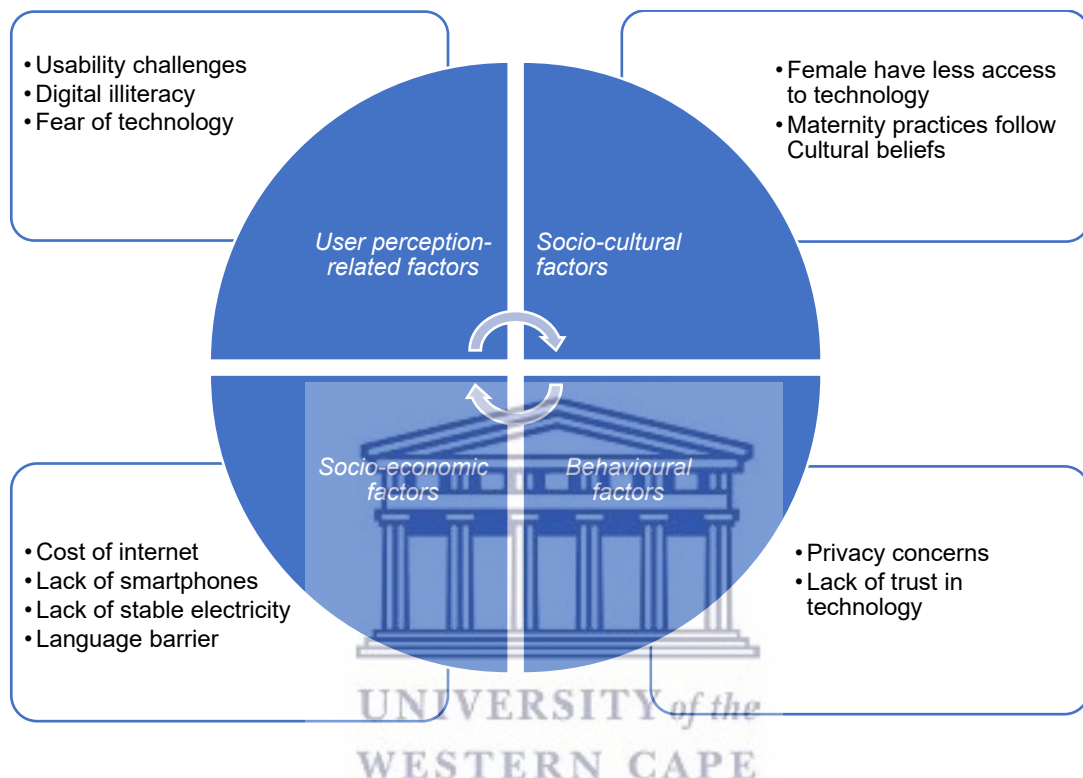


*Figure 5: The factors that influence the adoption of m-health applications*

The factors were derived from the findings to answer the primary research question, "What factors affect pregnant women's perceptions of adopting maternal health-related mobile applications in Sudan?" As seen in the figure, the key findings were grouped into four main factors. Behavioural factors included privacy concerns and lack of trust. It was found that participants had low trust in technology and were also concerned about their data privacy. Socio-economic factors revealed that lack of smartphones and stable electricity, cost of internet and language barrier. Socio-cultural factors included females having less access to technology. Lastly, user perception-related factors included usability challenges, a gap in digital illiteracy and a fear of technology. These factors significantly impacted and influenced the adoption of m-health applications by pregnant women in Sudan.

## 5.4    The attainment of the research objectives

The research used a qualitative approach to achieve the research objectives. Furthermore, it employed an explorative case study design, Objective 3 answered the primary research question, which is discussed in table 8 in section 5.2, and the recommendations in section 5.7 discuss objective 4. In order to answer the primary research question, "*What factors affect pregnant women's perceptions of adopting maternal health-related mobile applications in Sudan*?" our objectives were formulated in chapter one, and each objective has been achieved throughout the research. Four main objectives are required to answer the primary research question, which is explained in further detail in the following section.

### *5.4.1    Objective 1*

*"To identify a suitable framework to investigate the factors that affect pregnant women's perceptions towards adoption and utilisation of mobile technology in maternal health."*

The main technology adoption theories were reviewed to identify a framework for the study. The search targeted the theories and models explaining user acceptance of new technology. Four models were selected as the main technology acceptance models that attempt to identify and explain user behavioural intentions with similarity in concepts and variables. The models are the social cognitive theory (Bandura, 1986), the technology acceptance model (Davis, 1989), the Unified-theory of Acceptance and Use of Technology (Venkatesh, 2003) and the Diffusion of innovation theory (Rogers, 2003).

After a comparison of the four (Table 1) has been conducted based on the application of the technology adoption theories on m-health interventions adoption. The literature indicated that UTAUT had been mainly tested in healthcare (Kim & Lee, 2022) and that UTAUT constructs directly influence users' intentions to use e-health technologies. Venkatesh et al. (2003) compared UTAUT with other technology adoption and found that the UTAUT model explained 69% of technology usage intentions, while other models explained approximately 40% of technology adoption intentions. In addition, the UTAUT is a comprehensive model that combines the other theories mentioned above.

Several studies proved that the UTAUT model had been used to explain users' behavioural intentions to adopt m-health applications (Abbad et al., 2018). Furthermore, Nau et al. (2021) confirmed the applicability of the UTAUT model in the context of m-health intervention to record healthy body functions such as blood pressure. Moreover, Venkatesh, Thong and Xu (2016) concluded that the UTAUT model is important as it provides further growth in the

development of the technology acceptance and use theories and has endured stringent empirical validation.

The UTAUT model is stronger than other technology adoption models and has empirical evidence of its applicability and relevance to m-health adoption studies. Therefore, the UTAUT model was selected as the theoretical framework to guide this research; it was found to be most appropriate and relevant in achieving objective one.

### 5.4.2   Objective 2

*"To develop an instrument based on an appropriate theoretical framework to investigate mobile application adoption in Sudan settings."*

The instrument for objective 2 was an interview based on the UTAUT model. The interview questions were designed into five sections, and each section contained questions that captured pregnant women's perceptions as aligned with the UTAUT model. In addition, another section on social-cultural factors was added to the interview to explore the cultural beliefs of pregnant women in relation to the maternity practices in their communities.

UTAUT model was introduced with four constructs of acceptance and utilisation, which are performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FC) (Binyamin & Zafar, 2021). Jahanbakhsh et al. (2018) recognised perceived usefulness (performance expectancy) as the most important predictor of the user's behavioural intentions toward m-health technologies. Aria and Archer (2020) revealed that over 18 studies cited perceived ease of use (effort expectancy) as one factor influencing m-health adoption. The social influence construct was also investigated by Schneider et al. (2020) and the facilitating conditions. The authors concluded that they have a significant role in behavioural intentions and m-health adoption. These constructs formed the basis of the interview and as aligned with the UTAUT model, revealed insights on pregnant women's perceptions towards adopting m-health application in the Sudanese context, as required from objective two.

### 5.4.3   Objective 3

*"To identify the factors that affect pregnant women's perceptions on adopting maternal health-related mobile applications in Sudan."*

To answer the primary research question, UTAUT has been used as a lens to investigate the adoption of m-health among pregnant women in Sudan. The researcher identified in chapter four, together with table 7, discusses in detail the findings that affect pregnant women's

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perceptions of adopting m-health applications within the context of Sudan. UTAUT model identified or assessed factors that affect the adoption, and summary findings answer the primary research question. Figure 7 in section 5.3 provides the data analysis outcomes.

### 5.4.4 Objective 4

*"To make recommendations on how maternal health mobile applications could be successfully implemented in a developing country context."*

In order to increase acceptability and trust, it is recommended that m-health be promoted by healthcare providers and provide training to bridge the digital literacy gap. It is also recommended to have the technology compatible with various operating services and to ensure ease of use, user-friendly design interface, and local adaptations to m-health applications. Moreover, further research is needed to understand better the adoption of the m-health application among pregnant women in Sudan in the various states, not only the capital, Khartoum. The objective is answered in more detail in section 5.7.

## 5.5 Contribution of research

Mobile health technologies are promising tools that can transform healthcare delivery in developing countries like Sudan. They enable the development of solutions to tackle health problems and provide sustainable solutions. However, a lack of information in this field limits and hinders the adoption of m-health technology. Therefore, this research using the UTAUT model has made a major contribution by identifying the factors influencing the adoption of m-health applications, particularly among pregnant women in a developing country. During this study, no similar research was found in the context of Sudan. Essentially, this study provided new insight into respondents' attitudes toward mobile health applications in a developing country context and how various factors affect their acceptance and usage of these tools. This study also adds to the corpus of information in academia about the perspectives of pregnant women and using m-health applications to manage their pregnancy using primary data collection. Ultimately, a higher adoption rate of m-health among pregnant women may help reduce mortality rates among mothers and infants. It will also reduce the cost and pressure on healthcare systems as it supports early detection of possible complications and may assist pregnant women in avoiding harmful practices such as taking certain drugs with dangerous side effects.

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## 5.6 Limitations of the study

Limitations of the study were already discussed in chapter one, however, to briefly reiterate some of the limitations included the study being carried out in a capital city only (Khartoum), COVID-19 restrictions, language barriers and a small sample size.

## 5.7 Recommendation for future research

This section below provides recommendation as to how government can contribute to the successful uptake of m-health applications by Sudanese pregnant women. The succeeding sub-section provides recommendation for future research.

### 5.7.1 Recommendation for m-health development in Sudan

Despite the high penetration of mobile phones in Sudan, the adoption and usage of m-health applications among pregnant women are still low. In addition, there is currently a lack of e-health systems that link pregnant women to healthcare providers, including the Ministry of Health. Therefore, it is recommended that in Sudan, m-health application adoption should be introduced to pregnant women by the healthcare system to increase acceptability and trust. Training from clinics or midwives was also mentioned by participants in using m-health applications to bridge the digital literacy gap. Furthermore, adopting m-health applications reduces the costs and pressure on the Ministry of Health as it enables self-healthcare management, avoiding harmful practices during pregnancy and early detection of complications.

The second recommendation for application adoption is technology-related ease of use and simple application, as this is a strong deterring factor for adoption. Moreover, the application should be cost-effective. A social element may also be introduced as this is a major positive influence on m-health application adoption, where pregnant women can discuss relevant topics.

### 5.7.2 Recommendations for future research

Further research should investigate the development of m-health interventions in maternal healthcare in Sudan. Mobile health interventions have the potential to alter maternal healthcare delivery and are worthy of support and attention. Further research may also look at adapting m-health applications to the local level in terms of language, culture and other localised conditions.

This research studied the factors that influence the behavioural intentions of pregnant women towards m-health. However, further research can explore the barriers to m-health, such as lack of trust and fear of technology and cultural barriers. In addition, this research can also be

expanded to other states, not only the capital, Khartoum, to enable policymakers to cater better at a more local level.

## 5.8    Chapter Summary

The chapter aimed to summarise key adoption factors findings that emerged from the data analysis based on the UTAUT model. Furthermore, the chapter discussed the attainment of the study objectives, limitations and study contributions to the existing literature of similar studies. In addition, it contributes to providing new insight into pregnant women's attitudes toward mobile health applications in a developing country context and how various factors affect their acceptance and usage of these tools. The researcher recommended Further research to investigate the development of m-health interventions in maternal healthcare in Sudan. Along with recommendations on linking pregnant women to healthcare providers to facilitate the acceptance of the m-health tools for pregnant women, which would increase acceptability and trust. Moreover, in response to the primary research question, *What factors affect pregnant women's perceptions of adopting maternal health-related mobile applications in Sudan*? These factors revealed behavioural factors included privacy concerns and lack of trust, Socio-economic factors: lack of smartphone, lack of stable electricity, language barrier and socio-cultural factors included females having less access to technology and maternity practices strongly following cultural beliefs. Lastly, user perception-related factors included usability challenges, the gap in digital illiteracy and a fear of technology. These factors significantly influenced the adoption of m-health applications by pregnant women in Sudan. Essentially, this study provided new insight into respondents' attitudes toward mobile health applications in a developing country context and how various factors affect their acceptance and usage of these tools.

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**Appendix A: Research Information Sheet**

| **Project Title:** | Mobile technology adoption for improved maternal healthcare in Sudan |
|---|---|

**What is this study about?**

My name is Duha Zakaria a student at the University of the Western Cape (South Africa) pursuing a master's Degree in Information Systems. I am conducting a study to investigate the factors that influence pregnant women's perceptions towards the adoption of mobile health applications in maternal healthcare. This study is solely for academic purposes. The findings will help to inform and implement appropriate m-health interventions in the field of maternal healthcare in Sudan.

**Is it compulsory to participate and what if I initially agree, but decide to withdraw throughout the study?**

Your participation in this study is completely voluntary. Participants are free to withdraw at any time without any threat, penalty or detriment to their professional or personal capacity.

**What will I be asked to do if I agree to participate?**

As a participant who gives consent for your participation in this study, you will be required to participate in an interview with the researcher to discuss your views and opinions about the adoption of mobile health applications.

This will require about 20 to 30 minutes of your time. If you do not want to answer any question, you may refrain from doing so. This interview will be recorded on a recording device to be transcribed into readable information. This is to ensure that all feedback from the participants are accounted for and nothing is lost. If at any point in the interview, you are not comfortable for any reason, you may advise the researcher that you would like to stop the interview.

**Would my participation in this study be kept confidential and is my anonymity protected?**

You are not required to provide any personal details, such as your name, address or identity number. All other details such as your age, education, employment status etc is therefore anonymous.

**What are the risks of this research?**

Participation in this study bears no harm or risk to you physically or emotionally in any way.

**What are the benefits of this research?**

This study's results will add to the corpus of information in academia about the perspectives of pregnant women and using m-health applications to manage their pregnancy using primary data collection. Ultimately, a higher adoption rate of m-health among pregnant women may help reduce mortality rates among mothers and infants.

**What if I have questions?**

If you have any questions, feel free to contact either of the following persons:
- The researcher, Duha Zakaria on +249915200803 or via email at 3800096@myuwc.ac.za
- The study supervisor, Prof Shaun Pather on 021 959 32 48 or via email at spather@uwc.ac.za

**NOTE**: This research project has received ethical approval from the Biomedical Research Ethics Committee of the University of the Western Cape, which may be contacted via telephone on 021 959 411, and email: research-ethics@uwc.ac.za

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**Appendix B: Research Participant Consent Form**

| Project Title: | Mobile technology adoption for improved maternal healthcare in Sudan |
|---|---|

Please tick Yes or No to each of the following

| | Yes | No |
|---|---|---|
| 1. I confirm that I have read and understand the information sheet explaining the above research project and I have had the opportunity to ask questions about the project. | | |
| 2. I confirm that I am over the age of 18 years. | | |
| 3. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. | | |
| 4. I understand that should I not wish to answer any particular question or questions, I am free to decline. | | |
| 5. I understand my responses and personal data will be kept strictly confidential. | | |
| 6. I give permission for members of the research team to have access to my anonymised responses. | | |
| 7. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the reports or publications that result for the research. | | |
| 8. I agree for the data collected from me to be used in future research. | | |
| 9. I understand that there are no risks or harm to myself by participating in the survey. | | |
| 10. I agree to take part in the above research project. | | |

| If you have indicated YES to all the above, we may continue with the interview |
|---|

If you have any questions feel free to contact either of the following persons:
- The researcher, Duha Zakaria on +249915200803 or via email at 3800096@myuwc.ac.za
- The study supervisor, Prof Shaun Pather on 021 959 32 48 or via email at spather@uwc.ac.za

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**Appendix C: The Research Instrument- Interview Guide**

**Title of study:** **Mobile Technology Adoption for improved maternal healthcare in Sudan**

**Name of researcher:** **Duha Zakaria**

_____

### A. Introductory Remarks

Good Morning

My name is Duha Zakaria, I am a master's student at the university of the western cape, I am here today at Dream Specialized maternity hospital to conduct interviews with you for my study on mobile health applications. Today, I want to gain a better understanding of your perceptions and opinions of mobile health applications in maternal healthcare. As per the information sheet about my project, and the consent form you will note that the collected data is to be used for research purposes, only and you will not be identified, and your identities will not appear on the research materials.

Thank you for agreeing to take part in this study, your assistance in this study is most appreciated.

| Interview questions | Objectives |
|---|---|
| **Section A: Demographic data**<br>INTERVIEWER: What is your age<br>INTERVIEWER: What is the highest level of school you have completed?<br>INTERVIEWER: What is your marital status?<br>INTERVIEWER: Do you own a mobile phone?<br>INTERVIEWER: Do you have access to one if you do not own one?<br>INTERVIEWER: For how long have you been using a mobile phone?<br>INTERVIEWER: How often do you use your mobile phone?<br>INTERVIEWER: Have you heard about m-health applications before? If yes, what do you know about the application | The UTAUT model presents 4 moderating constructs viz, Age, Gender, Experience, and Voluntariness of Use. In this section these are probed further. |
| **Mobile health application overview** | |

| | |
|---|---|
| A brief overview will be presented about m-health applications in maternal health, its features and functionality – showed an application as an example – an actual application on a phone | |
| **Section B: Performance expectancy**<br><br>1. INTERVIEWER: Explain the circumstances under which you use your mobile phone to search for health care information?<br><br>2. INTERVIEWER: What benefits do you expect from using m-health application?<br><br>3. INTERVIEWER: From the list of features of m-health applications that were described to you, which of those do you believe will be most beneficial to you and why? | Performance Expectancy is defined as the degree to which the individuals believe that the use of the technologies will result in performance gains.<br><br>**Objective**: to examine the perception of pregnant women in relation to the benefits they expect in support of attaining "GOOD" maternal health when using a m-health application. |
| **Section C: Effort expectancy**<br>INTERVIEWER: What are some of the mobile phone applications that you use?<br><br>INTERVIEWER: Explain how confident you are in being able to use applications on your mobile phone<br><br>INTERVIEWER: Think about the situation in which you must use m-health application to support you during your pregnancy. How easy do you think it will be to use such a mobile application? Explain. | Effort Expectancy is defined as the perceptions of a potential user in respect of ease of use of the application.<br><br>Objective: is to examine the user's expectations in respect of the ease of use of m-health application. |
| **Section D:  Social Influence**<br>INTERVIEWER: Do you know anybody else who uses m-health application?  Explain who they are e.g. friends, family, people you have met at the clinic.<br><br>INTERVIEWER: Would you use m-health applications if they are using the application? Explain why. | Social influence: is the degree to which individuals perceive that influential people believe they should use a new information system.<br><br>Objective: to determine the influence of relatives and friends on pregnant women behaviors towards accepting and using m-health applications. |

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| | |
|---|---|
| **Extra question only to probe if necessary:** If your friends and relatives are satisfied with m-health would this encourage you to use the application? | |
| **Section E: Facilitating conditions**<br><br>INTERVIEWER: Describe the conditions which you feel are necessary to be in place for you to use mobile health applications<br><br>**Issues to probe only if necessary:**<br><br>INTERVIEWER: How would the affordability of data affect your decision towards adopting the application?<br><br>INTERVIEWER: Would you consider the confidentiality of information sent via the application as an impediment?<br><br>INTERVIEWER: Do you feel that you lack the skills to use an m-health application? | Facilitating conditions are defined as the extent to which an individual believes that there is technical and organizational infrastructure to support the use an information system.<br><br>Objective: To understand the existing facilitating conditions that are associated with the behavioural intentions of pregnant women towards technology usage.<br><br>**Facilitating conditions that could be important predictors towards m-health applications adoption are**<br><br>• **Digital literacy**<br>• **Affordability**<br>• **Confidentiality** |
| **Section F: social-cultural Factors**<br><br>• INTERVIEWER: Do you think your partner is allowed to make decisions for you?<br>• INTERVIEWER: Would you consider taking the decision to use m-health application without asking permission from your partner?<br>• INTERVIEWER: Do you feel that your culture beliefs hinder you from using technology? If yes, explain more about the cultural beliefs<br>• INTERVIEWER: Do you consider using technology as a more gender bias (male) and limited only for males? If yes explain why | This section explores the socio-cultural factors from perspective of gender differences in rural communities that gives women less access to technologies. The questions are designed to encourage women on elaborating more on their traditions and cultural beliefs that slow the process of empowering women in these communities.<br><br>• **Gender**<br>• **Culture influence** |

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**Appendix D: Example of an interview transcript**

INTERVIEWER: What is your age

INTERVIEWEE: I am 23 Years old

INTERVIEWER: What is the highest level of school you have completed?

INTERVIEWEE: I am postgraduate level, I have a master's degree

INTERVIEWER: What is your marital status?

INTERVIEWER: I am Married

INTERVIEWER: Do you own a mobile phone?

INTERVIEWEE: I have had a phone since I was in high school

INTERVIEWER: How often do you use your mobile phone?

INTERVIEWEE: I use my phone all day long for calls and using the internet.

INTERVIEWER: Have you heard about m-health applications before? If yes, what do you know about the application

INTERVIEWEE: Yes, I Have heard of it, I know it calculates the pregnancy weeks.

INTERVIEWER: Explain the circumstances under which you use your mobile phone to search for health care information.

INTERVIEWEE: I use my phone to search for health information related to pregnancy, medication usage and side effects.

INTERVIEWER: What benefits do you expect from using the m-health application?
INTERVIEWEE: Honestly, I do not know the pregnancy warning signs, and I am entirely dependent on the doctor. However, now that you have shown me the application, I am impressed by the quick access to information pregnant women would need to know. For example, I used to have severe headaches during my first two weeks, and I didn't realise that it is one of the pregnancy symptoms until I visited my doctor and he told me so.

INTERVIEWER: From the list of features of m-health applications that were described to you, which of those do you believe will be most beneficial to you and why?

INTERVIEWEE: The most beneficial feature is that provides weekly information depending on my pregnancy development I think it will be very supportive if I can have available information, I would feel comfortable and relaxed.

INTERVIEWER: What are some of the mobile phone applications that you use?

INTERVIEWEE: I use Whatsapp, Facebook, Uber and language learning applications.

INTERVIEWER: Explain how confident you are in being able to use applications on your mobile phone

INTERVIEWEE: it depends on my knowledge of the application and the complexity level of the application.
INTERVIEWER: Think about the situation in which you must use the m-health application to support you during your pregnancy. How easy do you think it will be to use such a mobile application? Explain.
INTERVIEWEE: if I live far from the clinic and I feel pain I think I will use the application to obtain information and determine if the symptoms are normal instead of going a long distance and waiting to see the doctor. so yes, the application will save me time and money if I can get the same information that I get from my doctor it will be great.

INTERVIEWER: Do you know anybody else who uses the m-health application? Explain who they are e.g. friends, family, and people you have met at the clinic.

INTERVIEWEE: At the clinic when I go for my appointment I usually meet and chat with pregnant women and mothers there, I made friends there and recently one of them told me about m-health applications, honestly after she showed me the application I wasn't excited to use it I felt it is difficult, however, I was influenced by her experience of using the application throughout her pregnancy, then I was convinced to use such applications

INTERVIEWER: Would you use m-health applications if they are using the application? Explain why.

INTERVIEWEE: As I told you yes, I followed my friends' recommendations to use the m-health applications to monitor my pregnancy, but it took me a long time to be convinced to use it

INTERVIEWER: Describe the conditions which you feel are necessary to be in place for you to use mobile health applications

INTERVIEWEE: Well, it depends on the application I think I will check the reviews first and see how it is regarding privacy and then decide. But yeah, in general, if the application stores my personal data safely, I will use it. Affordability will not be an issue.

INTERVIEWER: Do you think your partner can make decisions for you?

INTERVIEWEE: No, my husband cannot decide for me I make my own decision, my husband do not have the right to decide for me.

INTERVIEWER: Would you consider taking the decision to use the m-health application without asking permission from your partner?

INTERVIEWEE: no, I do not think he will mind, I know him well, so no I do not have to ask for his permission.

INTERVIEWER: Do you feel that your cultural beliefs hinder you from using technology? If yes, explain more about the cultural beliefs

INTERVIEWEE: Yes, our cultural beliefs hinder many women from using technology to support them during their pregnancy, for example, I know many women who are educated but refuse to use such applications they think it is against our religion and that it is our privacy we should not share personal information on a mobile application.

INTERVIEWER: Do you consider using technology as a more gender bias (male) and limited only for males? If yes explain why

INTERVIEWEE: No, we can all have the right to use technology. I mean men and women, so it is not gender bias. Maybe we women use it less than men, but it is because we have more responsibilities to do at home than men, therefore women do not have enough time to hold their mobile phones to browse the internet, play a game or download m-health applications.