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Assessing the impact of mobile technological innovation on maternal healthcare in South Africa

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Assessing the Impact of Mobile Technological Innovation on Maternal Healthcare In South Africa

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A research report submitted to the Wits Business School in the University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Masters of Management in the Field of Innovation Studies (MMIS)

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ABSTRACT

Background: Maternal mortality is a significant public health issue in developing countries due to its shocking magnitude and lower declining pattern. Identifying determinants and designing intervention will have an important role to overcome the problem. Ending preventable maternal mortality remains one of the world's most critical challenges despite significant progress over the past decade. These deaths are primarily from preventable causes before, during and after the time of giving birth. (Boerma, et al., 2015) Creative use of new mobile and wearable health information and sensing technologies (mHealth) has the potential to reduce the cost of health care and improve well-being in numerous ways. (Kumar, et al., 2013) The rapid growth in access to mobile phones and networks in Africa has created an opportunity for mHealth programs to impact the health of Africans positively. mHealth programs have the potential to contribute to innovative solutions to address health system challenges including (1) disparities in access to health services; (2) inadequacies of health infrastructure; (3) limited human resources for health; (4) cost to the individual of accessing health services; and (5) challenges in health financing. (African Strategies for Health (ASH), 2016) Therefore this study aimed to identify the correlates of mobile technology and maternal mortality in developing countries.

Method: This research report conducted used national and international databases of health metrics from 2011 to 2019. Using aggregates of health indicator data from Statistics South Africa (STATSSA), the World Health Organisation (WHO), World Bank, United Nations Development Programme (UNDP) and United Nations International Children's Emergency Fund (UNICEF) databases. Momconnect and Mum & Baby data were collected from Vodacom South Africa, the National Department of Health (NDoH) and Praekelt. The dependent variable was the maternal mortality ratio (MMR). In contrast, the independent variable was the numbers of subscribers for Momconnect and Mum & Baby, two national maternal mobile healthcare applications in South Africa. Data was compiled in excel and analysed using correlation tests and regression analysis.

Results: The maternal mortality ratio in South Africa is high. A significant relationship between the maternal mortality ratio and the adoption of mobile healthcare applications was observed. There were an inverse and significant correlation between the maternal mortality ratio and the diffusion of mobile technology.

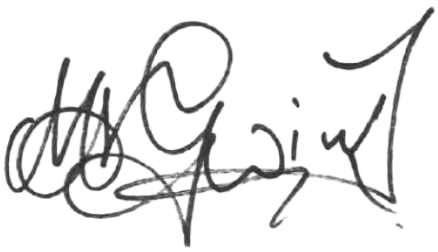
Conclusion: The maternal mortality ratio is correlated with mobile technology.

KEYWORDS

Maternal Mortality Ratio (MMR) in South Africa
Infant Mortality Rate (IMR) in South Africa
Causes of maternal deaths in South Africa
Maternal healthcare
Maternal healthcare in South Africa
Technology in Maternal Healthcare in South Africa
Mobile technology in Maternal Healthcare in South Africa
Mobile healthcare applications
Mobile technology impact of maternal healthcare
Mobile technology and maternal healthcare
MHealth
Innovation Diffusion Theory
Innovation Design Theory
Diffusion of innovation
Factors for innovation diffusion
Mobile healthcare

DECLARATION

I, **Misha Nédean Govind (Matee)**, declare that this research paper is my own unaided work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Management in the Field of Innovation Studies (MMIS) at the Wits Business School in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other University.



Signature: ……..

MISHA NÉDEAN GOVIND (MATEE)

On this the 28th day of February 2020 (Revision)

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LIST OF ABBREVIATIONS & ACRONYMS

ANC - Antenatal care

ARPU - Average revenue per user

EPMM – Ending Preventable maternal Mortality

GDP – Gross Domestic Profit

HIS - Health information system

HPHB – Healthy Parent, Healthy Baby

ICT – Information and communications technology

IMMR – Institutional Maternal Mortality Rate

IMR – Infant Mortality Rate

IoT – Internet of things

IVR - Interactive Voice Response

KPI – Key performance indicator

LMIC – Low Middle Income Country

MAMA Mobile Alliance for Maternal Action

MCH – Momconnect Help Desk

MDGR - Millennium Development Goals Report

MDGs – Millennium Development Goals

mHealth – Mobile Health

MMR – Maternal Mortality Rate

MNCH - Maternal, new-born and child health

NCCEMD – National Committee for the Confidential Enquiries into Maternal Deaths

NDoH – National Department of Health

SAID – South African National Identifier

SDGs - Sustainable Development Goals

SMS – Short message service

STATS SA – Statistics South Africa

Telecommunications Company/Companies – Telco(s)

UN – United Nations

UNDP - United Nations Development Programme

UNICEF United Nations International Children's Emergency Fund

USSD - Unstructured Supplementary Service Data

WEF – World Economic Forum

WHO – World Health Organisation

GLOSSARY AND DEFINITION OF KEY TERMS

3G population coverage: Percentage of the population covered by at a 3G mobile network refers to the percentage of inhabitants that are within range of a 3G mobile-cellular signal, irrespective of whether or not they are subscribers. This is calculated by dividing the number of inhabitants that are covered by a 3G mobile-cellular signal by the total population and multiplying by 100.

4G/LTE population coverage: Percentage of the population covered by a 4G/LTE mobile network refers to the percentage of inhabitants that are within range of a 4G/LTE mobile-cellular signal, irrespective of whether or not they are subscribers. This is calculated by dividing the number of inhabitants that are covered by a 4G/LTE mobile-cellular signal by the total population and multiplying by 100. Note that all LTE variants are included.

Analogue fixed-telephone lines: Analogue fixed-telephone lines refers to the number of active lines connecting subscribers' terminal equipment to the PSTN and which have a dedicated port in the telephone-exchange equipment. It includes all post-paid lines and those prepaid lines that have registered activity in the past three months. This term is synonymous with the terms 'main station' and 'direct exchange line' (DEL) that are commonly used in telecommunication documents.

Antenatal care (ANC) can be defined as the care provided by skilled health care professionals to pregnant women and adolescent girls in order to ensure the best health conditions for both mother and baby during pregnancy.

Diffusion: Diffusion of Innovations, which is the factors that influence market uptake, was made popular by Everett Rogers of the University of New Mexico. (Goffin & Mitchell, 2017) Introduced in 1962, the Innovation Diffusion Theory was fine-tuned by Everett Rogers (1995). Innovation diffusion theory focuses on understanding how, why, and at what rate innovative ideas and technologies spread in a social system (Rogers, 1962). (Wani & Ali, 2015) The way an innovation spreads through a population, according to Rogers, depends on six factors; relative advantage, observability, trialability, compatibility, complexity and perceived risk. (Goffin & Mitchell, 2017) Ismail Sahin, 2006, divided diffusion into four main elements; innovations, communications systems, time and social system.

DSL Internet subscriptions: Refers to the number of Internet subscriptions using digital subscriber line (DSL) services to access the Internet, at downstream speeds higher than or equal to 256 Kbit/s. DSL is a technology for bringing high-bandwidth information to homes and small businesses over ordinary copper telephone lines. It should exclude very high-speed digital subscriber line (VDSL) subscriptions if these are provided using fibre directly to the premises.

EHealth: The World Health Organisation defines eHealth as “the use of information and communication technologies (ICTs) for health too, for example, treat patients, pursue research, educate students, track diseases and monitor public health.” (Health S. D., 2012)

eLearning: the use of ICT for learning. It can be used to improve the quality of education, to increase access to education (for those geographically isolated or those who have access to inadequate learning facilities), and to make new and innovative forms of education available to more people. (Organization, Atlas of eHealth country profiles 2015: The use of eHealth in support of universal health coverage, 2015)

Ethernet LAN subscriptions refer to subscriptions using IEEE 802.3 technology. BPL subscriptions refer to subscriptions using broadband-over-powerline services. Users of temporary broadband access (e.g. roaming between PWLAN hotspots), users of WiMAX and those with Internet access via mobile-cellular networks are excluded.

Fertility rate, total (births per woman): Total fertility rate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with age-specific fertility rates of the specified year. (World, 2018)

Fibre-to-the-home/building Internet subscriptions: Refers to the number of Internet subscriptions using fibre-to-the-home or fibre-to the-building, at downstream speeds equal to, or higher than, 256 Kbit/s. This should include subscriptions where fibre goes directly to the subscriber’s premises or fibre-to-the-building subscriptions that terminate no more than 2 metres from an external wall of the building. Fibre-to-the-cabinet and fibre-to-the-node are excluded.

Fixed broadband subscriptions: Fixed-broadband subscriptions refers to fixed subscriptions to high-speed access to the public Internet (a TCP/IP connection), at downstream speeds equal to, or higher than, 256 Kbit/s. This includes cable modem, DSL, fibre-to-the-home/building, other fixed (wired)-broadband subscriptions, satellite broadband and terrestrial fixed wireless

broadband. This total is measured irrespective of the method of payment. It excludes subscriptions that have access to data communications (including the Internet) via mobile-cellular networks. It should include fixed WiMAX and any other fixed wireless technologies. It includes both residential subscriptions and subscriptions for organizations.

Fixed-telephone subscriptions: Fixed-telephone subscriptions refer to the sum of active analogue fixed- telephone lines, voice-over-IP (VoIP) subscriptions, fixed wireless local loop (WLL) subscriptions, ISDN voice-channel equivalents and fixed public payphones. This indicator was previously called Main telephone lines in operation.

IMMR refers to the institutional maternal mortality rate

Innovation diffusion is the process of the market penetration of new products and services that are driven by social influences, which include all interdependencies among consumers that affect various market players with or without their explicit knowledge. (Peres, Muller, & Mahajan, 2010)

Late maternal death: Death from any obstetric cause (direct or indirect) occurring more than 42 days but less than one year after delivery. (Organisation, World Health Organisation, 2019)

Live birth: The complete expulsion or extraction from its mother of a product of conception, irrespective of the duration of the pregnancy, which, after such separation, breathes or shows any other evidence of life such as the beating of the heart, pulsation of the umbilical cord, or definite movement of voluntary muscles, whether or not the umbilical cord has been cut or the placenta is attached. (ICD-10)

Maternal death is the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes. To facilitate the identification of maternal deaths in circumstances in which cause of death attribution is inadequate, ICD 10 introduced an additional category: Pregnancy-related death is defined as the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the cause of death. (Organisation, WHO Stat 2006, 2019)

Maternal health: Maternal health refers to the health of women during pregnancy, childbirth and the postpartum period.

Maternal morbidity: any health condition attributed to and complicating pregnancy and childbirth that harms the woman's well-being and functioning (Organisation, Strategies toward ending preventable maternal mortality (EPMM), 2015)

Maternal Mortality Rate (MMR): Complications during pregnancy and childbirth are a leading cause of death and disability among women of reproductive age in developing countries. The maternal mortality ratio represents the risk associated with each pregnancy, i.e. the obstetric risk. The maternal mortality ratio (MMR) is the annual number of female deaths from any cause related to or aggravated by the pregnancy or its management (excluding accidental or incidental causes) during pregnancy and childbirth or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, per 100,000 live births, for a specified year. (Maternal Mortality., (n.d.))

Millennium Development Goals (MDGs): In September 2000, building upon a decade of major United Nations conferences and summits, world leaders came together at the United Nations Headquarters in New York to adopt the United Nations Millennium Declaration.

The 8 MDG Goals

1. Eradicate extreme poverty and hunger
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality
5. Improve maternal health
6. Combat HIV/AIDS, malaria and other diseases
7. Ensure environmental sustainability
8. Develop a global partnership for development (Millenium Development Goals., n.d.)

mHealth: mHealth (or mobile health): a term for medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices. (Organization, Atlas of eHealth country profiles 2015: The use of eHealth in support of universal health coverage, 2015)

mVAS: Mobile Valued-Added Services are services offered by mobile operators to a consumer segment beyond standard voice, SMS, MMS and data services (GSM Association, Understanding the needs of pregnant women in South Africa,, 2014)

Mobile cellular subscriptions: Mobile-cellular telephone subscriptions, by post-paid and prepaid Mobile-cellular telephone subscriptions, refers to the number of subscriptions to a public mobile telephone service that provides access to the PSTN using cellular technology.

Mobile data subscriptions: Number of prepaid and post-paid mobile subscriptions that were used to access the Internet in the last three months, regardless of speed.

National Confidential Enquiry into Maternal Deaths Committee (NCCEMD): The NCCEMD is a ministerial committee of experts representing obstetrics, midwifery, anaesthesia and representatives from each of the nine provinces with the Department of Health's support. It was mandated to analyse reported maternal deaths and to make recommendations that would result in a reduction in the Maternal Mortality Ratio (MMR) (Deaths, 2018)

Noncommunicable or chronic diseases are diseases of long duration and generally slow progression. The four main types of noncommunicable diseases are cardiovascular diseases (like heart attacks and stroke), cancer, chronic respiratory diseases (such as chronic obstructed pulmonary disease and asthma) and diabetes. (Deaths, 2018)

Other fixed (wired) broadband subscriptions: Refers to Internet subscriptions using other fixed (wired) broadband technologies to access the Internet (other than DSL, cable modem, and fibre), at downstream speeds equal to, or higher than, 256 Kbit/s. This includes technologies such as Ethernet LAN and broadband-over-powerline (BPL) communications.

Satellite broadband subscriptions: Satellite broadband subscriptions refers to the number of satellite Internet subscriptions with an advertised download speed of at least 256 Kbit/s. It refers to the retail subscription technology and not the backbone technology.

Sustainable Development Goals (SDGs): The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its heart are the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries - developed and developing - in a global partnership. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests. (Sustainable Development Goals., n.d.)

Telecommunications sector: The telecommunications sector comprises fixed and mobile telecommunications services as well as the provision of Internet access.

Telemedicine: Telemedicine (or telehealth): involves the delivery of health services using ICT, specifically where distance is a barrier to health care. It falls under the rubric of eHealth. (Organization, Atlas of eHealth country profiles 2015: The use of eHealth in support of universal health coverage, 2015)

Terrestrial fixed wireless broadband subscriptions: Terrestrial fixed wireless broadband subscriptions refers to the number of terrestrial fixed wireless Internet subscriptions with an advertised download speed of at least 256 Kbit/s. This includes fixed WiMAX and fixed wireless subscriptions but excludes occasional users at hotspots and Wi-Fi hotspot subscribers. It also excludes mobile broadband subscriptions where users can access service throughout the country wherever coverage is available."

USSD (Unstructured Supplementary Service Data) is a Global System for Mobile (GSM) communication technology that is used to send text between a mobile phone and an application program in the network. Applications may include prepaid roaming or mobile chatting.

Wireless broadband subscriptions: Wireless-broadband subscriptions refers to the sum of satellite broadband, terrestrial fixed wireless broadband and active mobile-broadband subscriptions to the public Internet. The indicator does not cover fixed (wired) broadband or Wi-Fi subscriptions.

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CHAPTER 1

1.1 PURPOSE OF THE STUDY

The purpose of the research is to study how mobile technology, through the diffusion of innovation theory, has a positive correlation with maternal healthcare in South Africa. Many factors affect the numbers of maternal deaths; however, this study will focus on the diffusion of two mobile healthcare applications, Momconnect and Mum & Baby. The report examines the correlation between mobile technology the number of maternal deaths in South Africa.

1.2 RESEARCH FRAMEWORK

The research framework used for this report is explained below. An illustrative summary of the research framework (Figure 1) can be found on Annexure 4. Chapter 2, the literature review, will discuss the relevance of mobile technology and its diffusion characteristics, using the Diffusion of Innovation Theory and the Value Curve as theory. The literature review will introduce the two use cases of the research, Momconnect and Mum & Baby. The hypothesis statement; the research strategy, methodology and data analysis and testing are detailed in Chapter 3 of this paper. Chapter 4 will discuss the research findings, and Chapter 5 will provide a conclusion to the research paper and provide recommendations for future research.

1.3 CONTEXT OF THE STUDY

The study provides useful information to the Department of Health, mobile operators and stakeholders actively involved in innovation and healthcare innovation, on the adoption of innovative and preventative innovation in impacting maternal healthcare in South Africa. The report informs stakeholders in healthcare both public and private, the government and private sector entities actively involved in reducing cases of maternal deaths in the country, and understanding of the opportunities for the creation of innovative solutions and the improvement of existing solutions. The report provides insights to stakeholders on the technologies, knowledge and awareness that can be improved to support an increased rate of adoption of innovation aimed to address the problem of a high maternal mortality rate in the country. The report delves into innovation diffusion theory to present how the ubiquitous mobile network enables the diffusion of innovative solutions to have an impact on maternal health in South Africa

and examines the factors of diffusion theory and innovative design that can be implemented to increase the rate of adoption for a more impactful result.

1.4 PROBLEM STATEMENT

The problem this research report aims to address is whether mobile technology applications are an effective intervention to maternal healthcare in South Africa, due to the ability of mobile technology to diffuse the use of such applications.

In a world that is so often a frenzy of conflict and confusion, great innovation and invention have never had a more significant role to play in ensuring our wellbeing and survival. According to the World Health Organisation (WHO), around 10% of global gross domestic profit (GDP) is spent on healthcare, and, despite struggles against rigid safeguards and legacy systems, healthcare is seeing some of the most dynamic, exciting and vital new ideas of any industry. Some of the most notable health care disruptions in recent years has come from the application of technology; the deployment of big data to draw out lifesaving analysis and the creation of applications and devices to empower patients. These innovations take lessons from beyond the medical profession and apply them to a healthcare setting, driving efficiency, lowering costs and ultimately, saving lives. (Bidwell, 2017)

Healthcare in South Africa is at a critical juncture, facing profound inequalities between public and private healthcare, escalation of costs and critical shortages of healthcare professionals. In 2018, the health worker density was 6,9 per 1,000 population. (Health Worker Density and distribution., 2018) These and other challenges require immediate, innovative and scalable solutions. This is something the government is already planning with its introduction of a new National Health Insurance (NHI) scheme; however, the efforts of the government and healthcare providers need to extend beyond the immediate problems and look to the future by embracing innovative new system designs which reduce the cost, extend the reach and ultimately improve the health of the South African population. The potential for mobile health to make a real difference is made possible by the fact that South Africa now has a mobile penetration rate of 98%. This near saturation point, coupled with existing infrastructure, brand recognition, billing and data aggregation capabilities enables mobile stakeholders to begin looking at ways of increasing the limited reach of public and private healthcare services. (Friderichs, 2011)

The rapid growth in access to mobile phones and networks in Africa has created an opportunity for mHealth programs to impact the health of Africans positively. mHealth

programs have the potential to contribute to innovative solutions to health system challenges including:(1) disparities in access to health services; (2) inadequacies of health infrastructure; (3) limited human resources for health; (4) cost to the individual of accessing health services; and (5) challenges in health financing. (African Strategies for Health (ASH), 2016)

Healthcare systems must ensure that all women receive essential preventive and primary reproductive health care services. Including preconception and interconception care, comprehensive sexuality education, family planning and contraception and adequate skilled care during pregnancy, childbirth and the postpartum period. Programme planning must be people-centric, i.e. driven by people's aspirations, experiences, choice and perceptions of quality. Effective programme planning must be wellness-focused and population-based. Programmes must provide supportive primary and preventive care to the majority of women who are mostly healthy so that they can experience planned, uncomplicated pregnancies and births while ensuring that high-risk pregnancies and complications are recognized early. Interventions, when indicated, are undertaken in an appropriate and timely manner. Care must, therefore, emphasize the framework of availability, accessibility, acceptability and quality of services (AAAQ), as well as other human rights standards, such as participation, information and accountability, which are ensured through the cultivation of a robust enabling environment.

People in Africa use mobile phones very differently. Most striking is the accessibility of mobile. While penetration rates are by the standards of the developed countries low, how mobiles are informally shared between people, the formation of private resellers of mobile services and the provision of mobile phones for public use, all increase accessibility, even in rural communities. (Moving the Debate Forward - Africa: The Impact of Mobile Phones, 2005)

Effective healthcare solutions must integrate maternal and new-born care, protect and support the mother-baby relationship. The health outcomes for mothers and their new-born and children are inextricably linked; maternal deaths and morbidities impact new-born and child survival, growth and development. Therefore, an integral part of the framework is to protect and support the mother-baby relationship and to encourage the integration of strategies and service delivery for both, including linkage of vital registration data collected for mothers and their new-born and prevention of mother-to-child transmission of HIV. In effect, any policy or programme that focuses on either

strategy toward ending preventable maternal mortality (EPMM) maternal or newborn health should include consideration of the other. This is the principle of survival convergence. New-born health outcomes are enhanced when necessary care is provided without separation of the baby from its mother. Such integration of care is also more acceptable to women and families and efficient for the health system. Maternal and new-born health services should be delivered together whenever this can be done without compromising the quality of care for either. (Strategies toward ending preventable maternal mortality., 2015)

Solutions to healthcare challenges need not always come out of pharmaceutical companies, or high tech laboratories. Innovation systems are working together to solve social inequalities and challenges. These have the potential to diffuse across borders and be adopted by other countries and ecosystems and sometimes have the potential to solve an entirely different problem that the innovations initial purpose. The only way to reverse rising health costs while simultaneously improving outcomes for patients is by embracing new working methods and technologies. (Friderichs, 2011)

Momconnect and Mum and Baby are two mobile maternal healthcare applications implemented in South Africa in 2014 and 2016, respectively, using mobile technology. These initiatives have the common purpose of bridging the gap in providing preventative and advisory maternal healthcare information and addressing the country's challenge of access to professional healthcare workers and healthcare facilities. Although these two solutions are from different industry sectors, government (public) and mobile operator (private), they have the commonalities in the type of infrastructure used to communicate with end-users and the content or information being distributed, being the mobile network in the country and the mobile devices of the users.

1.5 SIGNIFICANCE OF THE STUDY

The research will present the significance of mobile healthcare technology as a useful innovation intervention through its diffusion characteristics, to have a resounding and sustainable impact on South Africa's maternal mortality ratio (MMR). Diffusion characteristics such as compatibility, accessibility and ease of use increase the adoption rate, increasing the diffusion of mobile healthcare application. This research report will show that the diffusion of mobile healthcare applications is significant because they have a greater impact on South Africa's MMR than the number of professional healthcare workers in the healthcare system and will get the country closer to the 2030 SDG MMR goal of 70 more effectively and as a more cost-effective

alternative to government. The research suggests that there are benefits to formulate policy around remote health care, that is low cost and scalable, having impact and access to large pockets of the population that are unable to access healthcare information. Mobile technology has the potential for the diffusion of services that will close the gap of inequalities to healthcare and information. Physicians will have to shift their paradigm on patient treatment and have to engage with technology that allows remote patient treatment. Mobile technology will offer efficient, low-cost interventions that can reach 99,5% of South Africa's population. (GSMA Intelligence., n.d.)

The research will include insight for active stakeholders in maternal healthcare, through the examination of the diffusion of innovation theory. These factors impact the rate of adoption of innovation and innovation design, on how current programmes can be improved and the opportunities for more significant innovation in maternal healthcare in South Africa.

1.6 DELIMITATIONS OF THE STUDY

- Geography: The research report examines the variables in South Africa.
- Data collection: Data used is secondary data, collected in national and international databases to represent health indicators such as maternal mortality ratio, number of maternal deaths and number of live births.
- Case studies: The research focuses on two mobile maternal healthcare applications in South Africa to provide maternal healthcare information.
- Regulation: Due to regulation around POPI (protection of personal information), the privacy of patient records and network provider privacy, personal interviews with users was not possible.
- Time frame: The timeline used for the data is 2014 to 2019, due to the two mobile applications being launched in this timeframe and completeness of data.

1.7 ASSUMPTIONS

- The data sets used for the research analysis are secondary and interpreted data. Secondary analysis is the analysis of data by researchers who will not have been involved in the collection of that data, for the purposes that were not envisaged by those responsible for the data collection.
- The total number of maternal deaths and the number of live births is the population of pregnant women in the period being examined. Refer to Table 3 in chapter 3.
- Linear regression analysis is based on six fundamental assumptions:

- The dependent and independent variables show a linear relationship between the slope and the intercept.
- The independent variable is not random.
- The value of the residual (error) is zero.
- The value of the residual (error) is constant across all observations.
- The value of the residual (error) is not correlated across all observations.
- The residual (error) values follow the normal distribution.

1.8 RESEARCH QUESTION

The research question is, does mobile technology innovation have an impact on the maternal mortality ratio in South Africa? The null hypothesis for this research is that mobile technology has no impact or change on the maternal mortality ratio in South Africa.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

The research report is based on a conceptual framework which correlates the diffusion of mobile technology, to improvements to maternal healthcare through its contribution to the industry value network. The research is contextualised in the literature review, which is divided into three main sections. The first two sections discuss the theory of diffusion of innovation and the value network. The final section discusses the maternal healthcare applications and introduces the two mobile healthcare applications examined in this research.

2.2 DIFFUSION OF INNOVATION

Diffusion of innovations, which are the factors that influence market uptake, was made popular by Everett Rogers of the University of New Mexico. (Goffin & Mitchell, 2017) Introduced in 1962, the Innovation Diffusion Theory was fine-tuned by Everett Rogers (1995). Innovation diffusion theory focuses on understanding how, why, and at what rate innovative ideas and technologies spread in a social system (Rogers, 1962). (Wani & Ali, 2015)

Diffusion is the process by which the innovation spreads from its source of the invention to its ultimate users or adopters. (Robertson, 1967) The way an innovation spreads through a population depends on several things: the characteristics of the innovation itself; the personal characteristics of the adopters, or customers; the communication channels through which they learn about and evaluate the innovation; and change agents – people such as teachers, consultants, public health workers and salespeople, who help adopters to get to grips with the innovation. (Goffin & Mitchell, 2017)

Another explanation for diffusion is the communication process through which an innovation travels through certain channels from a person, an organization, or any unit of adoption to another within a social system over time. Innovation can be an object, technology, behaviour, practice, program, idea, and be perceived as new to potential adopters. Adoption is the decision (i.e., acceptance or rejection) and the subsequent implementation, discontinuance, and or modification by an individual or an organization. Therefore, adoption is an individual or organizational process that leads to diffusion as a systemic process. Studies of adoption tend to focus on the perspectives of the adopters, while studies of diffusion usually examine the perspectives of the market and society as a whole. Although diffusion and adoption are commonly used together, the two are different levels of processes. (Kee, 2017)

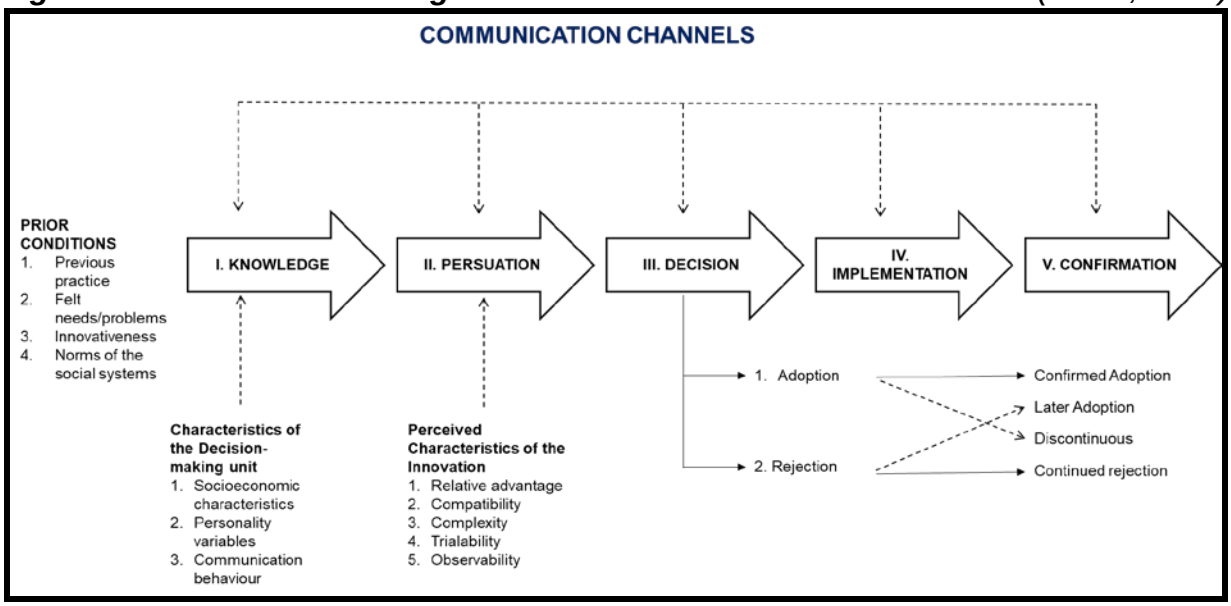
Innovation is regularly recognized as a critical component of industrialization and catch-up in developing countries. Fundamental innovation is costly, risky and path-dependent and to date, ground-breaking innovation is highly concentrated in a few rich countries, linked with specific forms of university science and research capacity, and amongst a small number of firms. Therefore, external sources of technology account for a significant component of productivity growth in most developing countries. If foreign technologies are easy to diffuse and adopt, a country with meagre technological capacity can follow a catch-up strategy to acquire and more rapidly deploy the most advanced technologies (Bell and Pavitt, 1993). In the current times, this is one emerging insight from the broad diffusion and impacts of mobile technologies and affiliated value-adding financial and health services (Aker and Mbiti, 2010). Technology diffusion to, and adoption by, developing countries is costly and conditional on factors that support the process (Keller, 2004). (Zanello, Fu, Mohnen, & Ventresca, 2016)

2.2.1 INNOVATION DECISION

Rogers described the innovation-decision process as an information seeking and information processing activity, where an individual is motivated to reduce uncertainty

about the advantages and disadvantages of an innovation. The process is illustrated in the figure below.

Figure 1 A Model of Five Stages in the Innovation-Decision Process *(Sahin, 2006)*



Prior conditions, as shown in the figure above, can be described as felt needs and problems. The literature review will examine the maternal healthcare challenges in South Africa. Despite investment in public health, the level of maternal mortality in South Africa is high. Of concern is the level of maternal mortality rate (MMR). Perhaps the most preventable cause of maternal death is access to healthcare information, healthcare workers and facilities to disseminate information at a time when it is needed the most. Pregnancy and childbirth are all too often a cruel and harsh lived experience for Africa's women, particularly the poor and women in rural areas. Almost 75% of women who die in childbirth would be alive if they had access to the interventions for preventing pregnancy and birth complications. (Africa Progress Panel, 2010)
Table 1 shows the contribution of direct, immediate causes and other maternal conditions contributing to maternal deaths from 1997 to 2007 in South Africa. Preventative causes such as maternal infections and parasitic diseases complicating pregnancy, childbirth and the puerperium, is the highest direct cause.

Table 1: Estimating maternal mortality and causes in South Africa: National and provincial levels 2014 (Udjo & Lalthapersad-Pillay, 2014)

	Per cent contribution to maternal deaths		
	1997	2001	2007
Direct causes of death*: South Africa			
Maternal haemorrage	10.4	10.0	6.5
Maternal sepsis	8.0	11.5	5.9
Hypertensive disorder	15.8	13.4	8.3
Obstructed labour	0.2	0.4	0.05
Abortion	9.5	10.5	5.0
Other maternal conditions	55.9	53.2	74.3
Other maternal conditions:			
Disorders related to pregnancy	3.1	3.0	5.0
Maternal care related to fetus, amniotic cavity and childbirth *problem*	0.7	0.6	0.4
Complications of labour and childbirth	4.6	4.1	2.7
Complications related to puerperium	8.0	6.2	3.5
Other obstetric conditions	42.1	40.4	63.4
Other obstetric conditions:			
Obstetric death of unspecified cause	0.3	0.8	1.0
Death from obstetric cause > 42 days and < 1 year after childbirth	0.2	0.2	0.1
Maternal infections and parasitic diseases complicating pregnancy, childbirth and the puerperium	4.9	7.1	18.0
Other obstetric conditions	36.6	32.3	44.3

* HIV/AIDS is an indirect cause of maternal death and so is not included in the table.

The lack of skilled doctors was recorded in 51% of women who died due to ectopic pregnancies, 33% due to miscarriages, and 46% cent due to pregnancy-related sepsis, 48% due to obstetric haemorrhage, 34% due to hypertension and 71% due to anaesthetic related cases. Overall, 39% of all maternal deaths with avoidable factors, lack of knowledge and skills of doctors was thought to have been contributory. In 25% of all maternal deaths with avoidable factors, lack of skilled nurses was thought to be contributory. (National Department of Health, 2018)

In the **knowledge stage**, the individual learns about the existence of innovation and seeks information about the innovation. There are three types of knowledge at this stage, awareness knowledge, how-to knowledge and principles knowledge. The individual may have all the necessary knowledge, but this does not mean that the individual will adopt the innovation because the individual's attitude also shapes the adoption or rejection of the innovation. The **persuasion stage** follows the knowledge stage because the individual shapes their attitude after they know about the innovation. While the knowledge stage is cognitive (or knowing) centered, the persuasion stage is affective (feeling) centered. At the **decision stage** in the innovation-decision process, the individual chooses to adopt or reject the innovation. In the **implementation stage,** the innovation is put into practice. Uncertainty about outcomes of the innovation can still be a problem at this stage, and the implementer may need technical assistance from

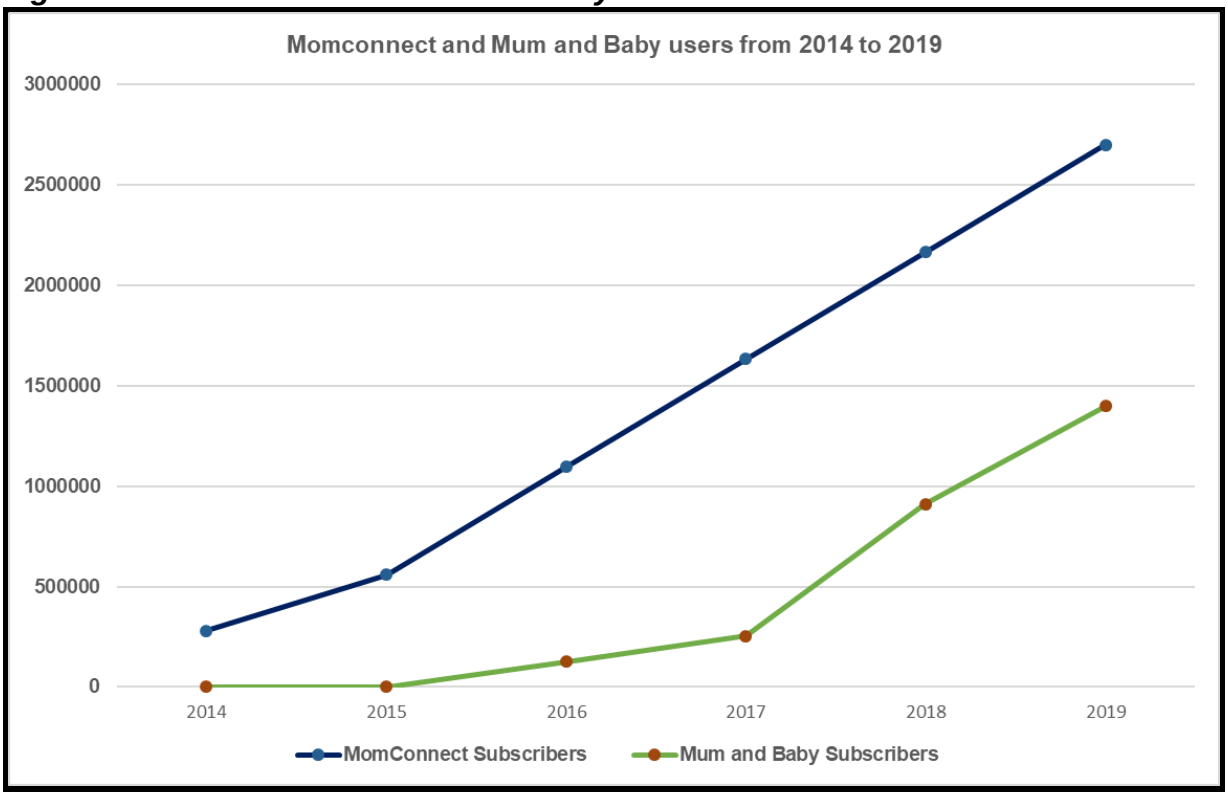
change agents to reduce the degree of uncertainty. Reinvention usually happens in the implementation stage. Reinvention is the degree to which a user changes an innovation during the process of its adoption and implementation. In the **confirmation stage**, the user looks for support for their decision. Depending on the support for the adoption of the innovation and the attitude of the individual; later adoption or discontinuance happens during this stage. **Discontinuance** can occur in two ways. Either replacement discontinuance, where the individual rejects an innovation to adopt a better innovation replacing it or disenchantment discontinuance where an individual rejects an innovation because they are not satisfied with its performance. (Sahin, 2006)

2.2.2 ADOPTION RATE OF INNOVATION

Adoption is the decision (i.e., acceptance or rejection) and the subsequent implementation, discontinuance, and modification by an individual or an organization. Therefore, adoption is an individual or organizational process that leads to diffusion as a systemic process. Studies of adoption tend to focus on the perspective of the adopters. In contrast, studies of diffusion usually examine the perspectives of the market and society as a whole. (Kee, 2017) They can also be referenced as a combination of the persuasion and the decision stages in figure 2.

The way an innovation spreads through a population, according to Rogers, depends on six factors or attributes. These factors are relative advantage, observability, trialability, compatibility, complexity and perceived risk. (Goffin & Mitchell, 2017) Rogers stated that individuals' perceptions of these attributes predict the rate of adoption of innovations. The number of individuals who adopted the innovation for some time can be measured as the rate of adoption of the innovation. (Sahin, 2006) Figure 3 below shows the number of users for Momconnect and Mum and Baby from 2014 to 2019. Momconnect launched in 2014 and Mom and Baby launched in 2016.

Figure 2: Momconnect and Mum & Baby users in South Africa from 2014 to 2019



Momconnect grew to national scale strikingly fast. The Minister of Health and the US Ambassador launched Momconnect together, receiving considerable media coverage that led to registrations at clinics all over the country. During the first month, nearly 50 000 pregnant women were registered on the system. The programme celebrated its millionth user in 2016 and by August 2017 had reached over 1.7 million pregnant women. They were representing 63% of all women attending their first antenatal care appointment.

2.2.3 RELATIVE ADVANTAGE

Relative advantage is the degree to which an innovation is perceived as better than the idea it supersedes. The relative advantage of an innovation, as perceived by members of a social system, is positively related to its rate of adoption. What does matter is whether an individual perceives innovation as advantageous? Over adoption is the adoption of innovation when experts feel that it should be rejected. Preventive innovations, defined as new ideas that an individual adopts now in order to lower the probability of some unwanted future event, diffuse more slowly than incremental (non-preventive) innovations. (Rogers E. , 2003)

Some technological advances result in considerable improvements in how health care is provided. In 1895, Roentgen discovered x-rays during his study of the light

phenomenon, and within six months, the first diagnostic radiograph was performed. X-rays gave physicians the ability to look inside the body without cutting it open. Through the end of 1896, the adverse effects of exposure to radiation were starting to be documented, the value of being able to see the structure and function of internal organs outweighed the disadvantages of radiation. X-ray technology diffused rapidly and is still the imaging modality that generates revenue today. (Cain & Mittman, 2002)
3 in 5 consumers say they are likely to switch to an operator that offers, a health hotline service. Alongside the availability and access to services, trust is a significant factor in consuming health care services. 1 in 3 women already trusts mobile operators to provide mHealth-related services. (GSM Association, Understanding the needs of pregnant women in South Africa,, 2014)

2.2.4 COMPATIBILITY

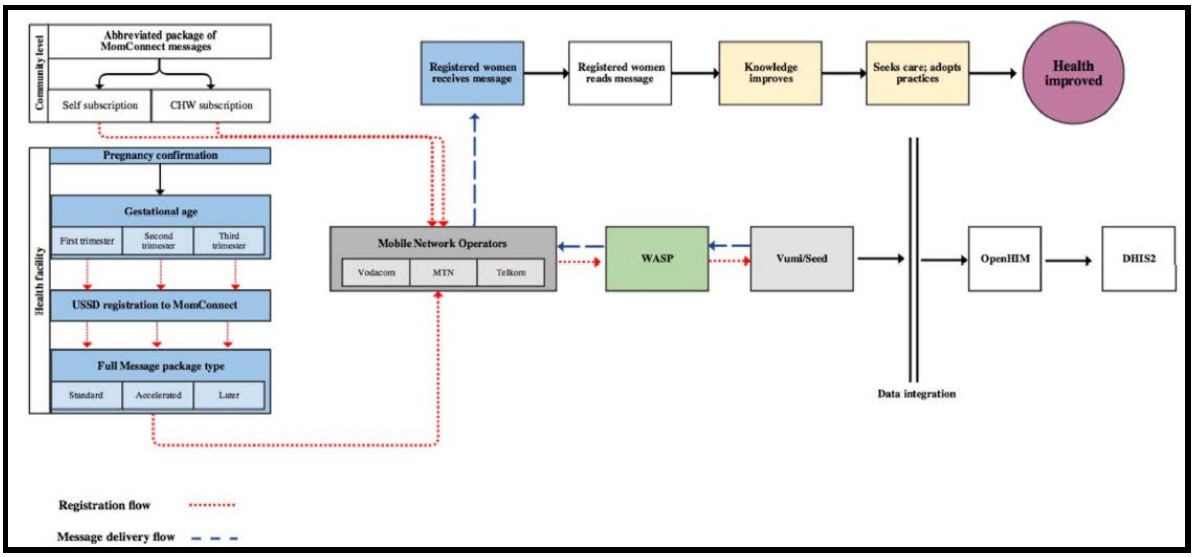
Compatibility is the degree to which an innovation is perceived as being consistent with the existing values, past experiences and the needs of potential adopters. The compatibility of innovation, as perceived by members of a social system, is positively related to its rate of adoption. Naming an innovation and positioning it relative to previous ideas are essential means of making innovation more compatible. (Rogers E. M., 2002) The familiarity of innovation, its compatibility with the existing environment and behaviour, is strongly linked to its diffusion. The more innovation can integrate and co-exist with technologies and social patterns already in place, the higher its prospects for adoption and diffusion. Precedent behaviour or an installed base of technology increases compatibility and improves the likelihood of diffusion. (Cain & Mittman, 2002)
In South Africa, nearly all pregnant women and mothers of children up to the age of two, including those at the bottom of the pyramid, have access to a mobile phone. Only 6% of BoP women do not own a mobile phone, and the majority of these women can access a mobile phone through a family member. (GSM Association, Understanding the needs of pregnant women in South Africa,, 2014)

2.2.5 COMPLEXITY

Complexity is the degree to which an innovation is perceived as challenging to understand and use. (Rogers E. M., 2002) The Momconnect messages were kept understandable and straightforward to laypersons emphasising inspiration and action, information and action with the broader aim of encouraging the mother to play an active role in the healthcare of herself and her infant. All messages were translated into South

Africa's 11 official languages and made available as an optional selection at registration. Maternal messages were bundled in two sets. The first set encourages pregnant women to attend facilities and receive antenatal care (ANC). The second focuses on essential new-born care, nutrition including infant feeding, immunisations and hygiene. Depending on the gestational age at the time of registration into Momconnect, women are eligible to receive one of three bundled message sets: (1) standard (sign-up before 30 weeks' gestation); (2) later (sign-up at 31–35 weeks' gestation) or (3) accelerated (sign-up at >35 weeks' gestation). (LeFevre, et al., 2018)

Figure 3 The pathway for pregnant women from the point of contact with the health system, to registration into Momconnect, message delivery and receipt and the intended effects on behaviour.



The Mum & Baby service is a profile-based tool, which means that when subscribers register, they are prompted to select the characteristics that best represent them. Registration for the Mum & Baby service is available through unstructured supplementary service data (USSD) or the Mum & Baby mobisite. Both registration platforms are free, require the same subscriber information, and make available the same health content. In the registration process, subscribers select their subscriber type (e.g. mother), age, geographic residence and language. The content is available in five languages. 95% of users registered through USSD rather than through the mobisite. (KPMG, 2019)

Figure 4: Mum and Baby USSD Registration steps

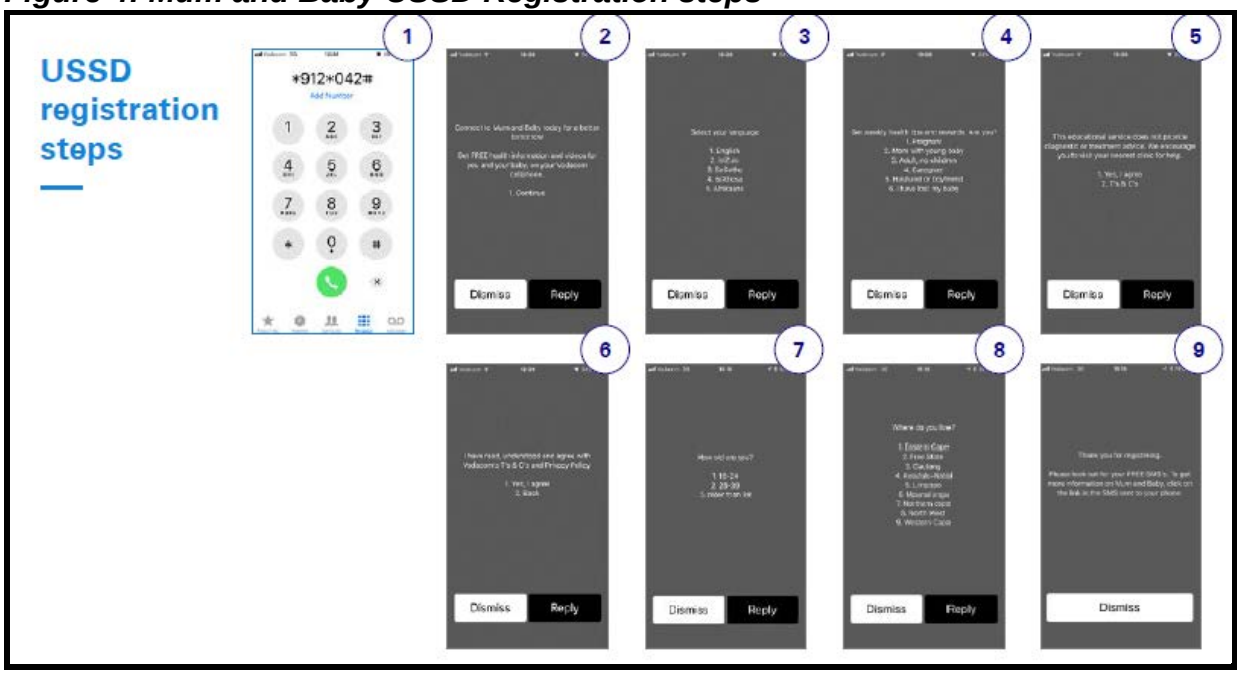
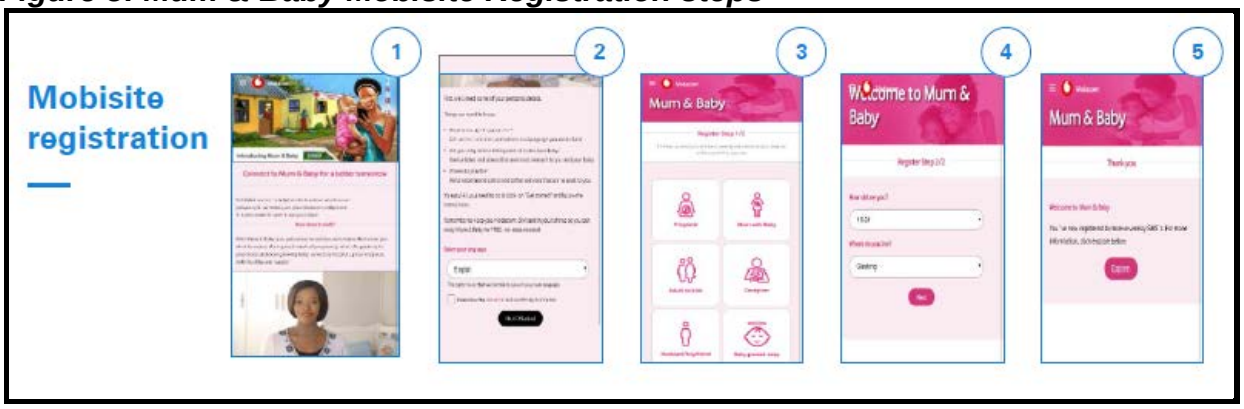


Figure 5: Mum & Baby Mobisite Registration steps



The content is tailored for distinct population groups (e.g. pregnant women, mothers, partners, caregivers). It provides messages that are based on the stage of gestation or the age of the child of the subscriber. The health content provided by the Mum & Baby service includes stage-based health information through various channels, which include:

- SMS messages: Nine distinct life stages (e.g. 0-3 months, 1-2 years old) with 24 to 104 unique messages delivered to subscribers of different types depending on relevance and the child's life stage;
- Articles: 280 health articles of approximately 200 words that are disseminated following a seasonal calendar in line with national health initiatives;
- Videos: 94 videos less than a minute in length providing health information relevant to pregnancy, new-borns and infant life stages; and
- Health tools: These include a due date calculator, immunisation calendar, and a pregnancy medicine safety checker. (KPMG, 2019)

- Innovations that reduce hassles are more likely to be successful. Features that go beyond the primary function of the technology and make it easier and more pleasant to use will increase its compatibility. (Cain & Mittman, 2002)

2.2.6 TRIALABILITY

Trialability is the degree to which an innovation may be experimented with on a limited basis. (Rogers E. M., 2002) In classic diffusion research, the easier it is to try out an innovation without having to commit to it fully, to discard an existing way of operating or to invest heavily in technology or training, the better the prospects for adoption and diffusion. (Cain & Mittman, 2002) Both Momconnect and Mum and Baby are free services. The low usage of the Mum and Baby mobisite may be a result of subscribers incorrectly believing that use of the mobisite will result in incurring costs, whether data or subscription. Mum and Baby have introduced a paid-for subscription service.

2.2.7 OBSERVABILITY

Observability is the degree to which the results of an innovation are visible to others. (Rogers E. M., 2002) Innovation, according to Rogers, is an idea, practice, or project that is perceived as new by an individual or other unit of adoption. Uncertainty is an important obstacle to the adoption of innovation. Innovations consequences may create uncertainty. Consequences are the changes that occur in an individual or societal system as a result of the adoption or rejection of an innovation. To reduce uncertainty of adopting the innovation, individuals should be informed about its advantages and disadvantages to make them aware of all its consequences. Communication channels is a process in which participants create and share information in order to reach a mutual understanding. Rogers states that diffusion is a specific kind of communication and includes these communication elements: an innovation, two individuals or other units of adoption, and a communication channel. From a study commissioned by Vodacom, KPMG reported that 98% of pregnant women and mothers surveyed agreed they had taken actions to improve their health as a result of the information provided through the Mum & Baby service. (The socio-economic impact of Vodacom's Mum & Baby., 2019) In a study done on whether Momconnect subscribers felt they benefited from the service, 96.5% of the users said the information they received from Momconnect was beneficial. Only one user (less than 1%) said it was not very useful. (Coleman & Xiong, 2017)

Diffusion is a very social process that involves interpersonal communication relationships. Thus interpersonal channels are more powerful to create or change strong attitudes by an individual. The innovation-diffusion process, adopter categorisation, and rate of adoptions all include a time dimension. The social system, as defined by Rogers, is a set of interrelated units engaged in joint problem solving to accomplish a common goal. (Sahin, 2006)

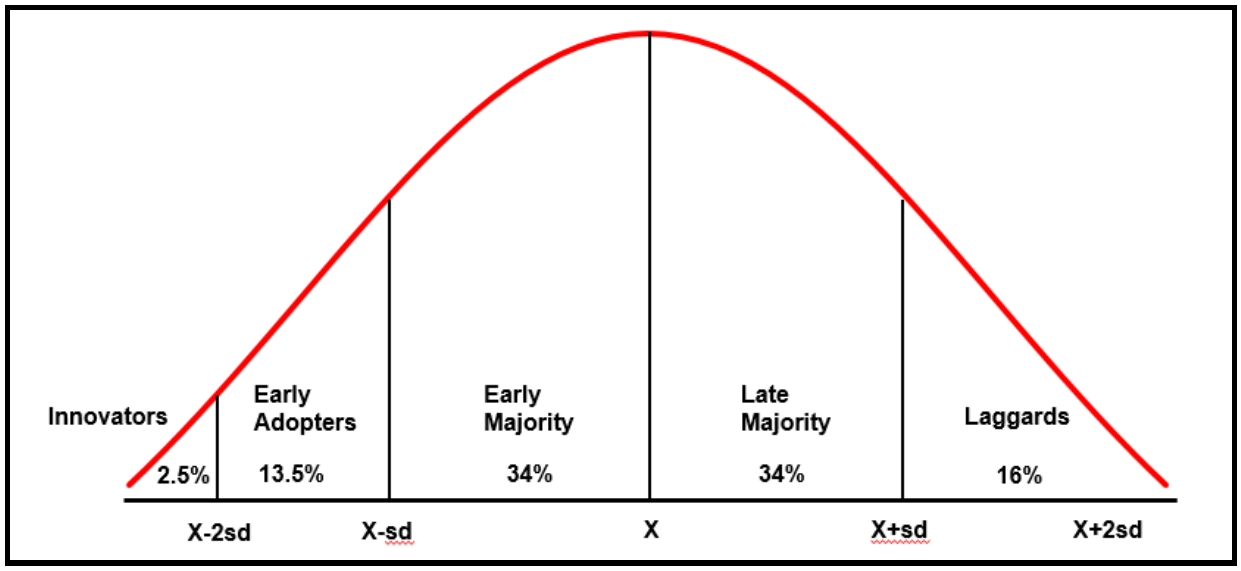


Figure 6 Adopter Categorisation based on Innovativeness *(Sahin, 2006)*

Figure 6 shows the adopter categorization based on innovativeness. Rogers defined the adopter categories as, the classifications of members of a social system based on innovativeness. Innovativeness is the degree to which an individual is relatively earlier in adopting new ideas than other members of a system. Innovativeness helps in understanding the desired and central behaviour in the innovation-decision process. Rogers also noted that incomplete adoption and non-adoption do not form this adopter classification. Only adopters of successful innovations generate this curve over time. (Sahin, 2006)

Several health interventions identified opinion leaders in the community of medical practitioners or members of the public. They then introduced innovations through these opinion leaders, thus speeding up the diffusion process. (Rogers E. M., 2002) How the distribution of benefits and risks map onto the interests, values and power distribution of the adopting system is critical to understanding how innovations diffuse. (Denis, Yann, Langley, Lozeau, & Trottoer, 2002)

2.3 VALUE NETWORK

2.3.1 VALUE CURVE

The value curve is a graphic depiction of the way an industry configures its offering to customers. It is drawn by plotting the performance of an offering relative to other alternatives along with the critical success factors that define competition in the industry. (Kim & Mauborgne, 2017) The figure below represents the value curve for healthcare facilities and mobile healthcare applications.

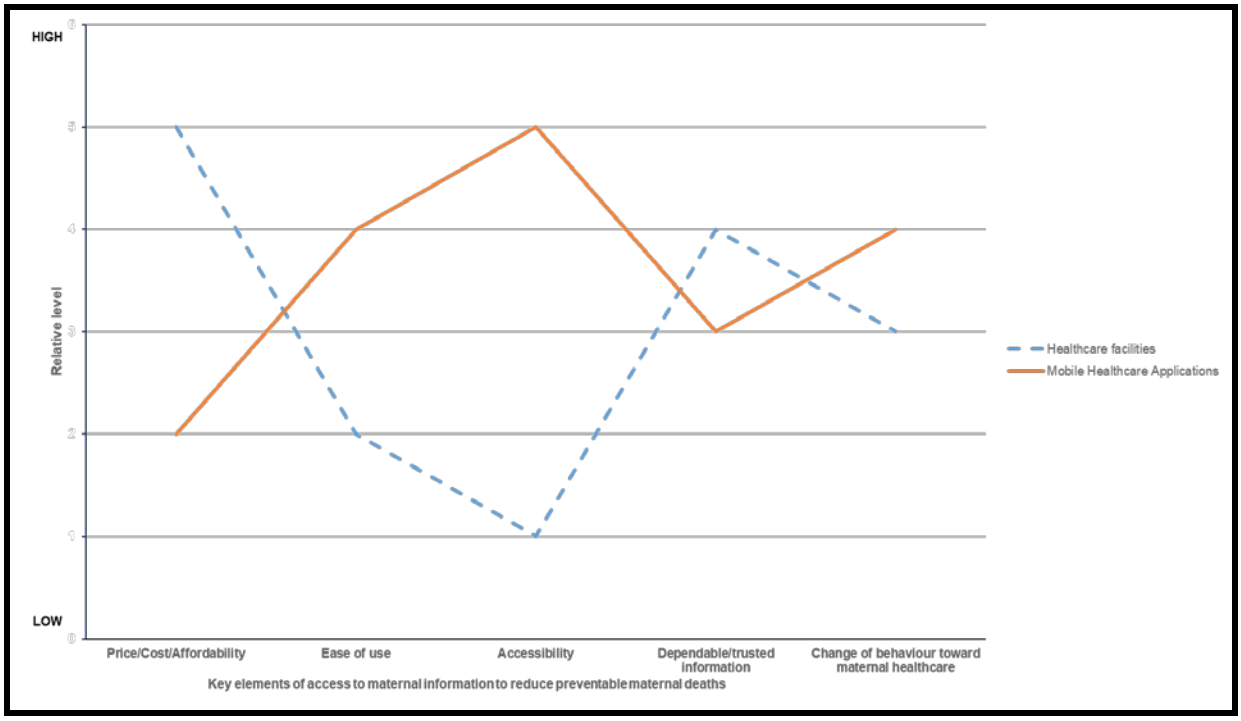


Figure 7: The figure represents the value curve for healthcare facilities and mobile healthcare applications

The value of a new value curve lies in asking four essential questions, illustrated in figure 8. By answering these questions, the industry addresses customer needs that can respond to competitor products or evolve the current product to provide more value for customers and even provide other uses for the service that are complimentary to the service.

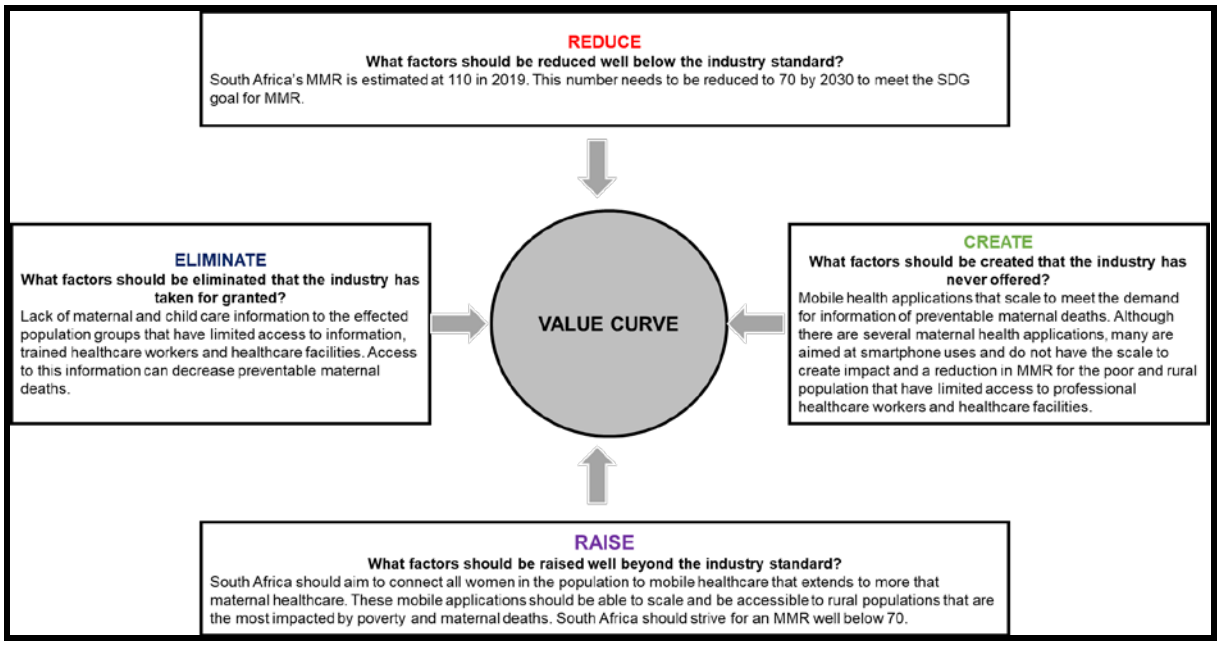


Figure 8: Creating a new value curve for mobile healthcare applications

A key determinant of the probability of an innovative effort's commercial success is the degree to which it addresses the well-understood needs of known actors within the value network. (Christensen, 2013)

Three distinct types of information that must be captured from customers to measure performance. They are "jobs" the customers are trying to get done when using a product or service, the "outcomes" they are trying to achieve when performing these jobs in a variety of circumstances and the "constraints" that stand in the way of them adopting or using a new product or service. Jobs, outcomes and constraints are critical inputs to the innovation process because they represent the three primary avenues in which managers can achieve growth.

2.3.1.1 JOB

Understanding the jobs customers are trying to perform, and the steps associated with executing those jobs is the first customer input needed to create growth through innovation. (Ulwick, 2014) Christensen et al. research introduced the jobs to be done theory, which tends to hold that traditional approaches fail since they do not sufficiently respect those jobs facilitating customers' lives. The theory holds that when a customer buys a product, he or she wants the product to do a job. (Oestreicher, 2009)

Understanding the jobs that customers are trying to get done when using a product or service is critical, as it dictates the area in which performance metrics or desired outcomes must be captured. What is also vital for growth is understanding what other

supporting or related jobs customers may be interested in performing when using a specific product or service.

Mobile technology can be used to address the “job to be done” for pregnant women, mothers, parents, partners and caregivers, using mobile healthcare applications. The customer need is easily accessible information that can provide relevant information on pregnancy and early childhood development and health. Table 2 shows the features of Momconnect and Mum & Baby that address the customer needs in comparison to how patients would traditionally access information from healthcare facilities. It also shows the relative advantage that mobile healthcare applications have over traditional healthcare facilities in addressing the customer need of accessibility to healthcare information.

Table 2: Comparison of Momconnect and Mum & Baby mobile applications and Traditional Healthcare Facilities

Momconnect	Mum & Baby	Traditional healthcare facility (Hospital/Clinic)
Stage-based health messages Subscription is limited to weekly messages. These messages will tell the mother more about Momconnect and encourage her to go to the nearest clinic to sign up for the full set of messages. The full set of messages comprises of approximately 150 messages, and the mother will receive between 2 and 3 messages per week. Messages are stage based so that the mother will get information that is relevant to the stage of their pregnancy. Messages include antenatal care and accessing care in labour, Diet and Nutrition, Non-pregnancy related Infections, Hypertension, New-born care, Breastfeeding and Immunisation.	Stage-based messages Subscribers receive three SMS messages per week containing health information pertinent to their child’s particular life stage. (e.g. 3-months pregnant) for the duration of the programme. 0-3 months; 4-6 months; 7-9 months; New-born (0-6 weeks); Infant (0-1 years); Toddler (1-2 years); Toddler (2-3 years); Young child (3-4 years); Young child (4-5 years)	The patient would only go to the clinic or hospital for their antenatal visits and their infant's vaccinations. This would be the only contact time the patient has with a healthcare provider. The first visit should take place within 12 weeks Second visit - Between 14 and 26 weeks Third visit - Between 28 and 34 weeks Fourth visit - Between 36 weeks and term
a text-based helpdesk that provides answers to pressing questions	There is no inactive helpdesk.	Appointments are short and pregnant women, or mothers do not have the opportunity to ask all their questions. If the patient has a question between antenatal visits, they

		would have to wait for their next appointment to ask the nurse these questions.
A library of health information accessed via a USSD menu	Information is available via SMS messages and a mobisite	There is no information repository readily available for patients at healthcare facilities.
A service rating feature that allows subscribers to report on the quality of services they receive at facilities.	Mum & Baby does not have a rating or feedback loop of patients experience at healthcare facilities.	The feedback is paper-based.
Integrating directly with the national health system, Momconnect presents decision-makers with control interfaces and dashboards to ensure that feedback from mothers reaches the highest levels of government	There is no integration of information captured on the user to feedback into the national health system.	Patient files are paper-based files. At state-managed clinics, patients registered on Momconnect will have an electronic record of their pregnancy and a record of their ANC visits.
A registration of pregnant women in public health ANC facilities and enrolment into a national register of pregnant individuals	There is no integration of patient information captured to feedback into the national health system. Healthcare workers cannot register the end user. The registration is a self-registration process.	The patient must open a medical file to be registered at an ANC clinic.
SMS messages are available in 11 languages	SMS messages are available in 5 languages	There is little to no language barrier at ANC healthcare facilities.
Information is in text and USSD format only	Both USSD and mobisite The following content types are available SMS messages Articles are Mobisite based and follow a structured health and seasonal calendar. They include Q&A with the ability to track progress over time. The articles are tailored to the four profile types and language preference and have a searchable archive. A full list of articles is available to subscribers on request. Videos-Subscriber receives one promotional SMS and one video per week for the duration of life stage. Tutorials consist of Informative, interactive five weeks deep dive into a specific health area. Tutorials are available as either mobisite or SMS tutorial. The tutorials include Q&A with the ability to track progress over time. Examples of tutorial topics are Pregnancy; Your baby's first year; Asthma in children &	The communication method of sharing information is verbal and occasionally using information booklets and pamphlets when available.

	adults; Hypertension; Cancer; Depression; Diabetes type1/2; HIV/Aids; Heartburn; Cholesterol; Backache; Smoking cessation; Osteoporosis; Urinary inconsistency; Allergy; ADHD; Alcohol abuse; Arthritis; Enviro-health; Menopause; Weight loss; Stress; Workplace issues. Interactive mobisite tools such as due date calculator; Immunisation calendar; Medicine checker (safety in pregnancy and breastfeeding); Am I Sick?; Medicine reminder; Health Directory	
Registration and access to information is free to the end-user	Registration and access to information is free to the end-user	The patient has to travel to the healthcare facility. This is an expense to the patient and can be expensive, depending on the distance to the healthcare facility.
Momconnect is aimed at pregnant women and mothers	Mum and Baby provide information tailored for pregnant women; new mothers; partners and caregivers.	The ANC visits and immunisation visits are attended in most cases by the mother only. Spouses, partners and caregivers do not have access to the healthcare workers to ask questions or get information regarding the pregnancy or infant.

Despite the existence of several mobile health applications including websites, mobisites, social networks and smartphone applications, these services were for the most part small in scale, clustered mainly in urban areas. They required the use of smartphones and internet access. This limits the usefulness of the technology in rural areas and in more impoverished communities, which were among the target populations identified by the NDoH in addressing maternal and child health.
Discovering what other jobs customers are trying to perform and determining which are poorly satisfied, opens doors to new opportunities for growth. Offering solutions that address auxiliary and related jobs often result in the creation of a breakthrough product or service. (Ulwick, 2014)
The use of the value curve and the four questions to establish a new value curve are a useful tool to understand which features the customers are not satisfied with and creates an opportunity to extend the mobile application to serve a broader set of needs for the same audience. The various forms of mobile technology in healthcare is demonstrated in a report by Mosa et al., 2012. Fifteen smartphone-based patient-

oriented applications were examined. The mobile applications were used for the management of chronic conditions, ear, nose and throat related and human fall detection. (Mosa, Yoo, & Sheets, 2012)

2.3.1.2 OUTCOME

For every job customers are trying to get done there exists a set of metrics that can be used to measure how well that job is being executed. If a job is well-executed across all the key dimensions of performance, then the job will be executed perfectly. The key is to obtain the right metrics against which to measure performance. These metrics must come from the customer. This can be determined in conversation with the customer to get the customer's desired outcome. (Ulwick, 2014) In a survey conducted, 95% of mothers and pregnant women respondents indicated that they agreed that the information provided through the Mum & Baby service had influenced their decision to breastfeed their child. Approximately 62% of respondents agreed, and a further 34% of respondents strongly agreed that the information received through the Mum & Baby service had influenced their decision to vaccinate their child. A high proportion of mothers and pregnant women respondents reported that they agreed that the information from the Mum & Baby service influenced their decision to visit a health centre for check-ups (97%). The Mum & Baby service offers health information on 24 different health topics that can be accessed through articles and tutorials. The health topic most accessed by mothers was information on teething. The most accessed tool for mobisite subscribers is the immunisation calendar, followed by the due date calculator. (KPMG, 2019) 96.5% of Momconnect users said the information they received from Momconnect was beneficial. Similarly, 98,2% of Momconnect users said the messages they received helped them make better maternal and infant health decisions. (Coleman & Xiong, 2017)

2.3.1.3 CONSTRAINTS

Constraints that prevent customers from gaining a product's full utility and prevent them from using a product altogether, represent significant opportunities for growth. To understand customer constraints, users of the product would explain under what circumstance they are unable to use a product and understand why the user is not obtaining the desired result. Non-users can explain what constraints are preventing them from adopting or using the product or service. It should be noted that not all

constraints can be overcome, but knowing they exist provides managers with the information they need to generate new growth potential. (Ulwick, 2014)
Understanding the constraints from Mum & Baby and Momconnect user feedback, could result in higher adoption of the service and more engaged user.

- 5% of respondents using the Mum & Baby service felt that the service had not influenced their decision to breastfeed their child.
- While users had used the immunisation related information and had learned new information through it, the majority would have taken their child for vaccinations in any case. Meaning having their children vaccinated could not be attributed to Vodacom's Mum & Baby service.
- Users already knew about visiting the hospital for check-ups without the information provided in the application.
- 12,4% of Momconnect users there were too many messages, and 7,1% felt there were too few messages.

Table 2 shows a comparison between Momconnect, Mum & Baby and traditional healthcare facilities. Mum & Baby is available in 5 languages with only 66% of the Mum & Baby users use the English content. To overcome a possible constraint of language and increase adoption, Vodacom could adopt the use of mobile technology such as Pulse Lab Kampala. Pulse Lab was the first UN Global Pulse Lab in Africa, which uses AI to take recordings of radio conversations around set themes, such as healthcare, refugees or local disasters, and translate the discussions into English. This provides valuable insights for local governments and humanitarian agencies to help inform life-saving policy decisions, such as where aid is needed. (GSMA Intelligence, The Mobile Economy Sub Saharan Africa 2019, 2019)

Mobile broadband networks have covered almost 1 billion additional people over the last five years. However, factors other than infrastructure are holding back the adoption of mobile internet, namely affordability, consumer readiness, and availability of locally relevant content and services. These barriers will slowly be overcome though, and by 2025 an additional 1,2 billion people will start using mobile internet for the first time, which will bring the total number of mobile internet subscribers globally to 5 billion (over 60% of the population). (GSMA Intelligence, The Mobile Economy 2020, 2020)

The concept of the value network, the context within which a firm identifies and responds to customer's needs, solves problems, procures input, reacts to competitors,

each firm’s competitive strategy, and particularly its past choices of markets, determines its perception of the economic value of new technology. These perceptions, in turn, shape the rewards different firms expect to obtain through the pursuit of sustaining and disruptive innovations. The way value is measured across networks. There are different rank-ordering of essential product attributes, even for the same product (Christensen, 2013)

Figure 9 is a high-level illustration, using Christensen’s concept of value network (Christensen, 2013) illustrates how the different actors in the value network evaluate the value and how they derive value from the network. Mobile connectivity requires continuous investment by operators to keep up with demand and provide the service consumers, and businesses expect, whether through densification in cities or plugging coverage gaps in rural areas. Governments at all levels can take steps to facilitate network deployment and expansion: simplifying and standardising planning procedures and regulations for site acquisition, colocation and upgrades of base stations and small cells; offering a reasonable expectation of approval for voluntary network-sharing deals while avoiding mandated sharing agreements; and adopting policies that reduce costs for mobile operators while spurring investment. To advance the mobile ecosystem and the digital economy overall, governments should strive, as much as possible, to lighten the regulatory load on the industry. When the business environment for mobile operators is less costly and more flexible, the performance and reach of mobile service expand, the pace of innovation increases and users’ confidence in the digital ecosystem is strengthened. (GSMA Intelligence, The Mobile Economy 2020, 2020)

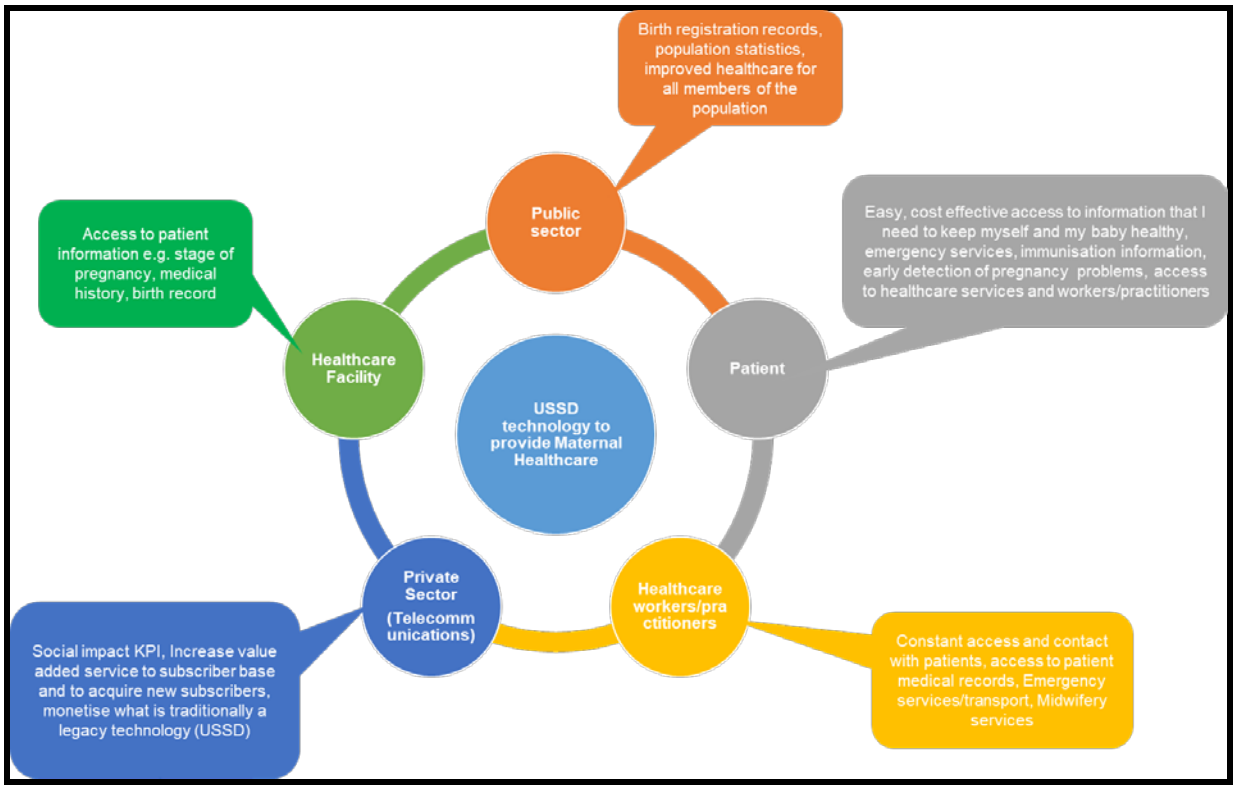


Figure 9: Illustration of Value Network derived from Christensen's concept of Value Network

Value can be defined in different ways, but at its heart, it is the production of new goods and services. Also crucial is whether what it is that is being created is useful. Are the products and services being created increasing or decreasing the resilience of the production system? Mariana Mazzucato describes value as to how different types of resources (human, physical and intangible) are established and interact to produce goods and services. Value extraction means activities focused on moving around existing resources and outputs and gaining disproportionally from the ensuing trade. (Mazzucato, 2018) Carriers are taking several approaches to grow revenues in order to offset declining voice and messaging revenues. Among other initiatives, carriers are exploring specific industry verticals where they can leverage their assets to produce new revenue streams. Healthcare is one such vertical. (Kent, 2014)

2.4 MOBILE HEALTHCARE APPLICATIONS

mHealth is the use of mobile and wireless technologies to support the achievement of health objectives. mHealth can be utilized for a wide variety of purposes, including health promotion and disease prevention, health care delivery, training and supervision, electronic payments, and information systems. (Africa Strategies for Health, 2016)

The main stakeholders in the healthcare process are healthcare consumers. Consumer-oriented healthcare is where patients are directly involved in the process of care. When the approach to healthcare is consumer-orientated the healthcare process is significantly improved. Technology can play critical roles in consumer-oriented healthcare. For example, making information accessible to consumers, integrating consumers' preferences into health information systems (HISs), remote monitoring and communication. Self-management and remote monitoring of patients are becoming viable solutions for the management of diseases with chronic conditions, and smartphones are playing a vital role. (Mosa, Yoo, & Sheets, 2012)

Women play an essential role in South African society. They account for 40% of the household income. 4 in 5 women are the household decision-makers in health matters. The majority are cognizant of their personal health needs and value the importance of securing the health of their family or their children.

As discussed earlier in the chapter, there are constraints to the value network that must be considered to produce an optimal outcome. Being less educated and because they tend to get pregnant much earlier in life, many South African women at the bottom of the pyramid (BoP) have fewer job prospects compared to non-BoP women. They are unable to move up the social ladder as they are likely to raise their babies or children on their own, as single parents, looking for job opportunities becomes more challenging unless they have a family member or a friend who can look after the babies or children while they are away. Providing BoP women, especially those who became pregnant for the first time, with relevant health education, is critical in order to help them become better prepared to manage their health as well as that of their babies.

In Cameroon, GiftedMom uses SMS and a smartphone application to provide information and reminders to its users about antenatal appointments, vaccination alerts, advice on health risks and complications, and information on family planning and breastfeeding. For users who cannot read or write, SMS messages can be sent via a voice application and translated into the local language. (GSMA Intelligence, The Mobile Economy Sub Saharan Africa 2019, 2019)

Nearly all households (98% mobile penetration) in South Africa have access to a mobile phone just like in developed markets. The case for using mobile phones to reach out to everyone, including South African BoP women (94% ownership among BoP women) especially for health education, remains compelling. Figure 10 shows the penetration of mobile devices in South Africa. (GSM Association, Understanding the needs of pregnant women in South Africa,, 2014)

Growth in the mobile industry has driven an unprecedented increase in digital inclusion in low- and middle-income countries. Since 2014, mobile operators have connected 700 million new subscribers, and another billion have gained access to the internet through a mobile phone. Mobile technology is fit for scale to reach the majority of the population and the penetration of the mobile device provides the diffusion factor of compatibility.

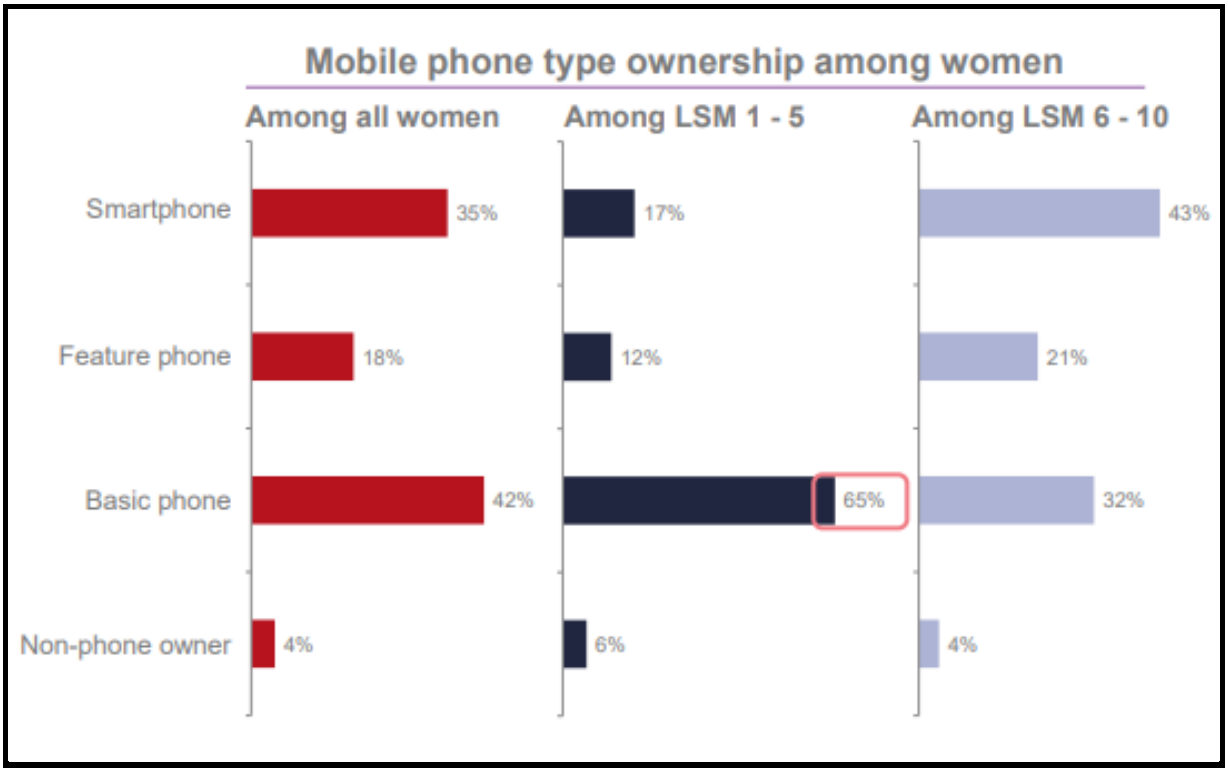


Figure 10 Mobile phone ownership of women in South Africa (2014) *(GSM Association, Understanding the needs of pregnant women in South Africa,, 2014)*

The Mobile Alliance for Maternal Action (MAMA) project was one of the precursors to Momconnect in South Africa and elsewhere globally has deployments in Bangladesh, India and Nigeria. In South Africa, the MAMA project was implemented over three years and led to the registration of over 500,000 women.

In Bangladesh, MAMA is delivered through the *Aponjon* program, which provides maternal health information messages through Interactive Voice Response (IVR) or SMS. Since its inception 6 years ago, over 1.9 million women have been subscribed, and services expanded to include a doctor's line and two additional mobile applications. In India, mMitra provides MAMA maternal messages using IVR to an estimated 600,000 subscribers across three states. Elsewhere, evidence on other maternal mobile messaging programs is emerging. The Kilkari program in India provides once weekly stage-based IVR health information messages on topics ranging from family planning to maternal and child nutrition to pregnant and postpartum women up to 1-year post-partum. To date, the program has been scaled across 12 states and estimates having

reached a minimum of 2 million pregnant women, new mothers and their families in the last 1.5 years; corresponding to a population level coverage of pregnant women of approximately 15%.

2.4.1 MOMCONNECT

In August 2014, the National Department of Health (NDoH) implemented Momconnect as a national digital maternal health program that implements the South African mobile health (mHealth) strategy and the National Health Normative Standards Framework for Interoperability in electronic health (eHealth). As the first digital health program communicating with people at scale, Momconnect enrolled more than half a million women from all regions of the country in the first year of operation, representing approximately half the number of pregnancies in the public health sector. (Seebregts, Barron, Benjamin, Tanna, & Fogwill, 2016)

Momconnect aims to register all pregnant women in South Africa to a national database, through the use of cellphone-based technologies integrated into maternal, child and women's health services. It provides a means for pregnant women to receive stage-based relevant information about their pregnancy and also allows them to provide feedback on the services that they receive at clinics. (MomConnect Operational Report 2015., 2015) Also, Momconnect delivers increased access to contraception and improved coverage of breastfeeding, to address the relatively high maternal mortality rate (MMR) and child mortality rate in South Africa. In 2016, South Africa's MMR was 138 per 100,000 live births. (Sustainable Development Goals., n.d.) South Africa's Sustainable Development Goal (SDG) for MMR is 70 deaths or less per 100,000 live births by 2030. (African Strategies for Health (ASH), 2016)

In sub-Saharan Africa, 94% of pregnant women received antenatal care (ANC), 76% received the recommended four ANC visits, 96% delivered in a health facility, 97% had births attended by a skilled provider and 84% attended postnatal care within two days following birth. High rates of service utilisation have been underpinned by programmes like Momconnect, which aim to empower pregnant and postpartum women with knowledge and bolster the utilisation of health services. Momconnect is one of the only five mobile health information messaging programmes to have scaled to over 1 million beneficiaries and the only programme to have attained population-level coverage of more than 60%. While a multitude of factors underpins the programme's successful implementation, perhaps none are more critical than the pregnant and postpartum women in South Africa who form the backbone of our communities, and the health workers who work tirelessly to register women and provide vital health services. The

commitment to technology use in the health sector is a critical component of the Department of Health's vision to embrace innovative strategies for improving health services. (Pillay Y, 2018)

Interconnectivity

One of the critical advantages of Momconnect over the Mum and Baby intervention is that the Momconnect technical solution has several linked elements that enable pregnant women to receive information about their health and also that of their infants. They also enable interaction with a helpdesk. Women can ask for more information and give feedback to provide the impetus for the supply side of the health system to improve the quality of care. The Momconnect platform is linked to the national healthcare system, which allows critical information regarding the registration of the pregnancy and birth. This information strengthens the statistics gathered by the country of birth registrations and late birth registrations. Information regarding HIV treatment and health conditions and diseases can also be collected and available in the healthcare system, which means that healthcare facilities and healthcare workers have this medical record at hand and available when needed. It can send relevant healthcare information to the user. The challenge of birth registrations can be addressed by looking at examples of mobile technology applications, for example, in Tanzania and Ghana, mobile-enabled digital birth registration has seen more infants registered early or on time (within the first year), in some cases almost quadrupling registration rates (from 8.9% to 30.3% in Mbeya Tanzania). In some regions in Ghana, more than 90% of births are now registered digitally, all contributing to goal 16.9 'By 2030, provide legal identity for all, including birth registration'. (GSMA Intelligence, The Mobile Economy Sub Saharan Africa 2019, 2019)

Subscribers initially receive messages encouraging them to register their pregnancy at an antenatal clinic. Women attending the antenatal clinics are registered into a central database. Based on the estimated gestational age of the foetus, stage-based messages are sent to the pregnant woman. Similar messages linked to the age of the infant are sent after delivery. Variables linked to the identification of the women and the facilities allow Momconnect to link with other national information systems under development. The women can choose one of the 11 official languages for messages. (African Strategies for Health (ASH), 2016)

Usability

The Momconnect technology platform was designed to maximise usability at several levels. At an end-user level, phones made use of simple USSD functionality that is

familiar to end-users and ubiquitously available across cell-phone types throughout the country. The backend infrastructure was optimised to use the fewest possible components and most straightforward possible standards, and user-friendly administration tools were developed to assist with long-term maintenance.

Interoperability

Momconnect' s technical infrastructure makes use of the architecture provided by the National Health Normative Standards Framework (HNSF), which implements interoperability standards and profiles across different applications that may also be extended to support additional health services.

2.4.2 MUM & BABY

Vodafone has set a goal to connect an additional 50 million women living in emerging markets to mobile by 2025 and to use mobile technologies to enhance the quality of women's lives through programmes that enable financial inclusion, improve health and wellbeing and build education, skills and entrepreneurship. To support the achievement of this, in partnership with Vodafone's South Africa-based subsidiary, Vodacom Group, the Mum & Baby service was launched in March 2017. Mum & Baby service was launched with Vodacom South Africa's technology partner Mondia Media and the mobile content supplier MobiStar. Mum & Baby is a free-of-charge mHealth intervention that provides subscribers with stage-based information and advice on pregnancy, neonatal and child care in the form of educational articles, tutorials, videos and tools. Mondia Media manages the Mum & Baby service technology platform from a functionality perspective and collects the registration and usage data by tracking the online content accessed. It manages the dissemination of SMS messages, oversees the lifecycle of the subscriber and provides reports and analytics relating to mobisite usage.

Vodacom has diversified the audience of the mobile application to include fathers, partners and caregivers, not just pregnant women and mothers. The content provided is also customised for these segments. The mobile healthcare application extends to mobisite, offering a more comprehensive range of content that cannot be optimally utilised on USSD or SMS. The content features were discussed earlier in the literature review. It is perhaps this diversification of content and platform that has seen users steadily grow over the three years, almost matching the growth of Momconnect. Vodacom has also introduced premium content, which is available on a daily and weekly subscription. The mobisite also expands the offering to include smartphone

users, making the customer pool larger that Momconnect, which predominantly serves a feature phone audience.

Interconnectivity

Mum and Baby is positioned as a benefit of the Vodacom Siyakha tariff. The Siyakha proposition is focused on South Africans who do not have easy access to health information, education, jobs and social connectivity. The platform facilitates digital inclusion through targeted offers and content, focusing on four main pillars: social connectivity, health, education and jobs, with zero data charges. Since its launch in 2017, free access to the Vodacom Mum and Baby portal has impacted the lives of 1.4 million parents and guardians across South Africa. The platform democratises access to healthcare, providing pregnant women and new parents with health information by registered medical professionals on health issues about pregnancy and young children up to the age of five. In a bid to commercialise the platform, Vodacom launched Mum and Baby Premium in 2018 and have seen good uptake of the service, with users having a 10% higher average revenue per user (ARPU) and three more active days on the network than non-users. (Vodacom Integrated Financial Report, 2019)

Usability

Reaching those at the bottom of the pyramid – at scale – requires easily accessible and cost-effective technologies. Low-tech mobile tools meet this need and beyond. Low-tech, offline solutions drive several mobile innovations reaching scale today in Africa and Asia Pacific that are driving impact on the lives of low-income mobile users. Even in the age of smartphones, low-tech solutions are indispensable to addressing the SDGs. (GSMA Intelligence, The Mobile Economy Sub Saharan Africa 2019, 2019) The number is 2G connections in South Africa in the fourth quarter of 2019 was 31,878,182, and the number of basic handsets in South Africa in the same period was 30,048,382. The Mum & Baby mobile applications aim is to address the inclusion of this base, in addressing the challenge of providing healthcare information. 95% registered through USSD rather than through the mobisite. (KPMG, 2019)

Interoperability

Mum & Baby is available on both basic handsets and smartphones. Allowing customers to access the platform according to their preference and access. 96% of Mum & Baby subscribers, access and receive Mum & Baby service information only by SMS, while

only 4% receive it from the mobisite. Indicating approximately 49,000 subscribers access the mobisite.

2.5 SUMMARY

The literature review has provided the theoretical context of innovation diffusion and the characteristics of diffusion aligned to the mobile technological innovation in maternal healthcare in South Africa. Preventive innovations, such as Momconnect and Mum and Baby, are defined as mobile healthcare applications that an individual adopts in order to lower the probability of some unwanted future event, being a high maternal mortality ratio. (Rogers E. , 2003) Reaching those at the bottom of the pyramid at scale requires easily accessible and cost-effective technologies. Low-tech mobile tools meet this need and beyond. Low-tech, offline solutions drive several mobile innovations reaching scale today in Africa and the Asia Pacific that are driving impact on the lives of low-income mobile users. Even in the age of smartphones, low-tech solutions are indispensable to addressing the SDGs. (GSMA Intelligence, The Mobile Economy Sub Saharan Africa 2019, 2019)

Mobile technology addresses disparities in access to health services by allowing the subscriber to receive personalised messages based on their stage of pregnancy or perhaps a pre-existing condition such as hypertension. Mobile healthcare is lowering the chances of a preventative cause of maternal death. Access to healthcare workers is one of the leading causes of maternal deaths in South Africa and subscribers no longer have to wait for clinic visits to be able to ask their questions or find the information. Momconnect has an interactive helpdesk, and questions are attended to by a nurse. Both Momconnect and Mum & Baby are free to register and use, addressing the inequalities in the cost of accessing health services and health financing. Momconnect and Mum & Baby have had an adoption rate of over a 2,5 million subscribers over the last five years, which is an adoption rate of over half a million users annually.

The literature review examined the value network and value curve and how these tools can be used to design innovative solutions to address customer needs and improve platforms to extend features to address complementary needs. The examination of mobile healthcare applications illustrates how mobile technology can deliver information around preventable diseases and maternal healthcare issues that can change user behaviour to effect a positive impact on maternal healthcare in South Africa. Mobile technology has a network that can scale these interventions to masses and especially to the parts of the population that are poverty-stricken and need the information the

most because these rural parts lack skill healthcare workers and healthcare facilities but have access to a mobile device. Mobile technology lends itself to a scalable solution that increases the diffusion of innovation.

CHAPTER 3: RESEARCH STRATEGY AND METHODOLOGY

3.1 LINEAR REGRESSION

Simple linear regression is a model that assesses the relationship between a dependent variable and an independent variable. The simple linear model is expressed using the following equation:

$y = mx + b$

$y = slope * x + intercept$

3.2 P-VALUE

A p-value is used in hypothesis testing to accept or reject the null hypothesis. The p-value is the evidence against a null hypothesis. The smaller the p-value, the stronger the evidence that to reject the null hypothesis.

P-values are expressed as decimals but converted to a percentage. For example, a p-value of 0.0355 is 3.55%. This means there is a 3.55% chance your results could be random. A large p-value of 0.9 (90%) means your results have a 90% probability of being completely random and not due to anything in the test. The smaller the p-value, the more significant the result.

A hypothesis test, compares the p-value to the alpha level. Alpha levels are shown as a percentage.

3.3 STATEMENT OF HYPOTHESIS

The null hypothesis assumes that the independent variable did not result in a difference in the dependent variable (zero difference) and there is, therefore, no relationship between the dependent and independent variable (the slope is zero). The alternative hypothesis states the opposite and is the hypothesis the research is determining. It means that the independent variable does have a relationship with the dependent variable and a change in the independent variable affects the dependent variable.

This research used hypothesis testing to collect data that signified a relationship between a dependent (maternal deaths in South Africa) and independent variables (uptake of mobile healthcare applications). The type of investigation used was the correlation testing and regression analysis to test the independent and dependent variables and to determine whether the null hypothesis is true. Figure 1 illustrates the research framework and design. This chapter will discuss the research steps in detail.

3.4 RESEARCH DESIGN

The study was conducted using national and international databases of health metrics from 2011 to 2019 from StatsSA, the NDoH, WHO, World Bank, UNDP and UNICEF databases to identify the number of maternal deaths and the maternal mortality ratio in South Africa. Data was collected from Vodacom South Africa, Mondia Media and Praekelt.

The research is aimed at determining the causal relationship between the independent variable, is the adoption of mobile healthcare applications and the dependent variable being the MMR in South Africa. The research report examined how significant the impact the independent variable has on the dependent variable and the strength of the relationship between the two variables. Regression testing was used to measure these factors.

The research process is as follows

- State the null and alternative hypotheses
- Specify α and the sample size
- Select an appropriate statistical test
- Collect data
- Compute the test statistic based on the data
- Determine the p-value associated with the statistic
- Reject or accept the null hypothesis by comparing the p-value/significance F to α (i.e. reject the null hypothesis if $p\text{-}value < \alpha$)

3.5 RESEARCH SUBJECTS

A variable is any given data series that is considered to be a component for statistical measurement. An independent variable is an attribute that describes the fundamental characteristic of the entity being described. On the other hand, a dependent variable is any variable that is influenced by the independent variable due to causality relationship. At this point, the change in the dependent variable is observed and recorded. For

example, in this report, the dependent variable of maternal deaths can potentially change (increase or decrease) with the change in the independent variable the diffusion or uptake of mobile healthcare applications, as we explore later.

The research subjects are the users of Momconnect and Mum and Baby.

The table below examines the report data points. It also represents these users as a percentage of the population, based on the assumption that the total number of maternal deaths and the number of live births, is the population of pregnant women in the period being examined. Over the last five years, the population for mobile healthcare applications is a significant size of the total number of pregnancies population. Where the percentage of mobile healthcare application users is over-indexed, this could be a result of mothers using the mobile application post-birth, as both mobile healthcare applications provide vital post-birth healthcare information for the mother and infant healthcare.

Table 3: Number of births and maternal deaths and the percentage of population compared to the total population

YEAR	TOTAL NUMBER OF PREGNANCIES (LIVE BIRTHS + MATERNAL DEATHS)	% OF POPULATION SIZE FOR MOMCONNECT SUBSCRIBERS/USERS	% OF POPULATION SIZE FOR MUM & BABY SUBSCRIBERS/USERS	% OF POPULATION SIZE FOR MOBILE HEALTHCARE APPLICATION SUBSCRIBERS/USERS
2011	1035918	0%	0%	0%
2012	1030943	0%	0%	0%
2013	1022013	0%	0%	0%
2014	1020029	27%	0%	27%
2015	967409	58%	0%	58%
2016	911081	120%	14%	134%
2017	922062	177%	27%	205%
2018	928188	233%	98%	331%
2019	885066	305%	158%	463%
TOTAL(S)	8722708	31%	16%	47%

3.6 DATA COLLECTION

International country-level data collected by specialized agencies of the United Nations (such as WHO for health data), and other intergovernmental organizations such as World Bank Data and UN data which compile data from many different sources. Country-specific estimates for maternal mortality were based on the most recent interagency estimates. For South Africa with relatively complete data from national death registration systems, data was used directly for estimating and projecting maternal mortality ratios. StatsSA provided national-level data for maternal deaths reported in South Africa and the number of live births reported in South Africa. Vodacom South Africa provided subscriber numbers and subscriber profiles for Mum & Baby

users in South Africa. Praekelt and the NDoH provided national-level data on Momconnect users and user profiles.

The research will use data points in (units/individual) for Momconnect and Mum and Baby as the independent variables and the number of maternal deaths (units/individuals) in South Africa for the period of 9 years (2011 to 2019). Table 4 shows the data used for the report.

- The number of subscribers/users for Momconnect was obtained from the National Department of Health and verified against the subscriber numbers obtained by Praekelt.
- The number of Mum and Baby subscribers/users was obtained by Mondia Media and was verified by numbers obtained from Vodacom.
- The MMR was obtained from Statistics South Africa, and these numbers were cross-checked with the MMR numbers from the international databases. The latest and most complete data was used for the report.

3.6.1 MATERNAL MORTALITY RATIO AND MATERNAL DEATHS IN SOUTH AFRICA FROM 2011 TO 2019

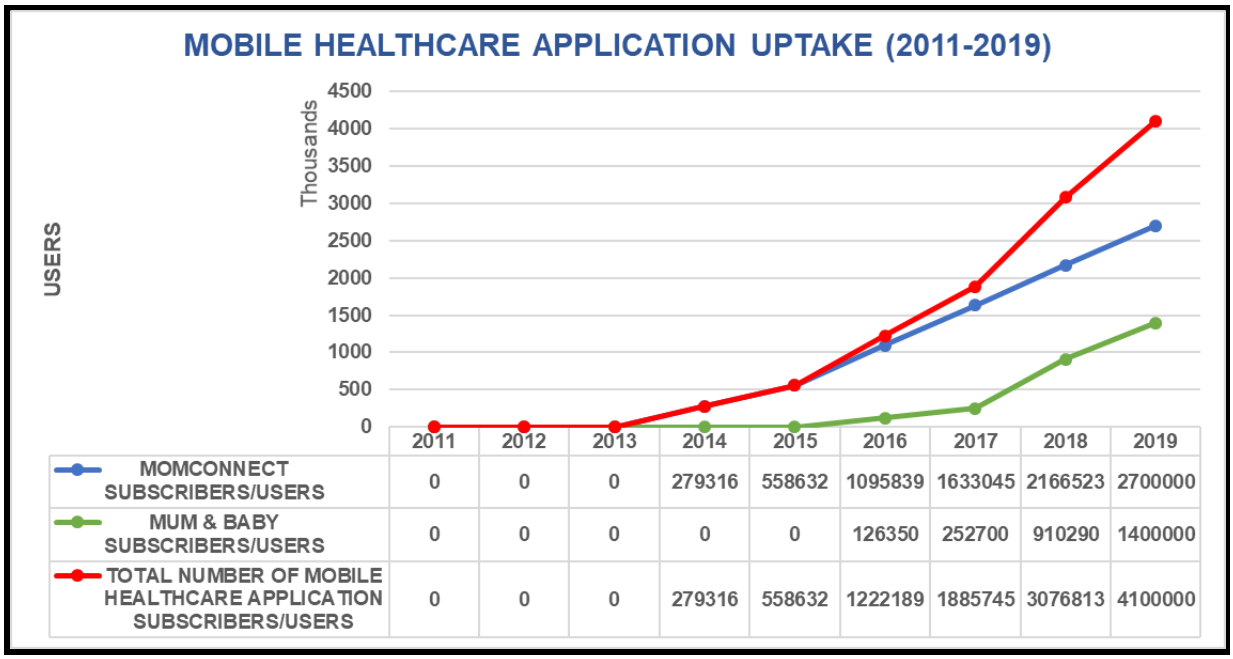
Maternal Mortality Ratio (MMR) is calculated as follows,
MMR = All maternal deaths occurring within a reference period (usually one year) x 100,000 ÷ Total number of live births occurring within the reference period

Table 4: South Africa's Maternal Statistics from 2011 to 2019

YEAR	RECORDED LIVE BIRTHS	MATERNAL DEATHS	MMR	MOMCONNECT SUBSCRIBERS/USERS	MUM & BABY SUBSCRIBERS/USERS	TOTAL NUMBER OF MOBILE HEALTHCARE APPLICATION SUBSCRIBERS/USERS
2011	1034325	1593	154	0	0	0
2012	1029378	1565	152	0	0	0
2013	1020533	1480	145	0	0	0
2014	1018603	1426	140	279316	0	279316
2015	966201	1208	125	558632	0	558632
2016	909912	1169	129	1095839	126350	1222189
2017	920966	1096	119	1633045	252700	1885745
2018	927113	1075	116	2166523	910290	3076813
2019	884093	973	110	2700000	1400000	4100000

3.6.2 MOMCONNECT AND MUM AND BABY

The number of subscribers/users measures the population for Momconnect and Mum & Baby from 2011 to 2019. The graph below shows the data points used for the research.



	2011	2012	2013	2014	2015	2016	2017	2018	2019
MOMCONNECT SUBSCRIBERS/USERS	0	0	0	279316	558632	1095839	1633045	2166523	2700000
MUM & BABY SUBSCRIBERS/USERS	0	0	0	0	0	126350	252700	910290	1400000
TOTAL NUMBER OF MOBILE HEALTHCARE APPLICATION SUBSCRIBERS/USERS	0	0	0	279316	558632	1222189	1885745	3076813	4100000

Figure 11Adoption of Mobile Healthcare Applications 2011 to 2019

Momconnect has seen rapid growth from launch in 2014 and continues to grow exponentially. The influence can explain the difference in the adoption rate that public health facilities and healthcare workers have on the enrolment into the Momconnect application. Service providers must invest in their change agents, as they have the potential to speed up the diffusion of mobile technology. A change agent is an individual who influences clients' innovation decisions in a direction deemed desirable by a change agency (Rogers E. , 2003) This could infer why the Momconnect has enjoyed a steeper adoption rate than Mum & Baby. Momconnect has the advantage of nurses doing bulk registrations and encouraging mothers and pregnant women to register to the Momconnect platform. Figure 4 in chapter 2, illustrates and confirms this difference in the adoption rate between Momconnect and Mum & Baby.

3.7 DATA ANALYSIS AND TESTING

Data were obtained from different sources and compiled with excel. Each variable was checked for completeness and consistency. Whenever a series of data obtained, the most recent one was used. Correlation analysis was performed to ascertain the degree of the relation between MMR and the independent variables. All associations and tests were said to be significant at $p < 0.05$.

3.7.1 CORRELATION TESTS

Correlation tests were performed and are shown below to test whether there is a correlation between the Momconnect, Mum and Baby and the number of maternal deaths populations. The correlation coefficient, which is a value between -1 and +1, shows how strongly two variables are related to each other. A correlation coefficient of +1 indicates a perfect positive correlation. As variable X increases, variable Y increases. As variable X decreases, Y decreases. A coefficient of -1 indicates a perfect negative correlation. A negative correlation would show that as variable X increases, variable Y will decrease. A correlation coefficient near 0 indicates no correlation.

The regression test uses maternal deaths as a unit to test the null hypothesis. Below shows the correlation between maternal deaths and MMR to validate that the two measures are positively correlated. Table 5 shows a 99,3% correlation between maternal deaths and MMR, which is an almost absolute correlation.

Table 5: Correlation test between Maternal Deaths and the Maternal Mortality Ratio (MMR) in South Africa

	MATERNAL DEATHS	*MMR*
MATERNAL DEATHS	1	
MMR	0.992860317	1

Table 6: Correlation test for maternal deaths and Momconnect

	MATERNAL DEATHS	*MOMCONNECT SUBSCRIBERS/USERS*
MATERNAL DEATHS	1	
MOMCONNECT SUBSCRIBERS/USERS	-0.92959919	1

Table 6, shows the correlation coefficient between the number of maternal deaths and the number of Momconnect subscribers is close to -1 and therefore shows an almost perfect negative correlation between maternal deaths and the uptake of Momconnect mobile healthcare application. The more users subscribing to Momconnect will result in less maternal deaths. Table 7 shows the same for Mum and Baby's correlation test. The correlation coefficient is close to -1, which infers a negative correlation.

Table 7: Correlation test for Maternal Deaths and Mum & Baby

	MATERNAL DEATHS	*MUM & BABY SUBSCRIBERS/USERS*
MATERNAL DEATHS	1	
MUM & BABY SUBSCRIBERS/USERS	-0.74125751	1

3.7.2 REGRESSION TEST 1

- Dependent variable (y) – Maternal Deaths in South Africa from 2011 to 2019
- Independent variable (x) – Number of subscriber/users of Momconnect from 2011 to 2019

Null Hypothesis = 0. Meaning a change in the number of Momconnect users has no significant change to the number of maternal deaths and therefore no change to the MMR.

Alternative Hypothesis means that a change in the number of Momconnect users has a significant change to the number of maternal deaths and therefore a change to the MMR.

Refer to Annexure 1 for the detailed regression test and summary

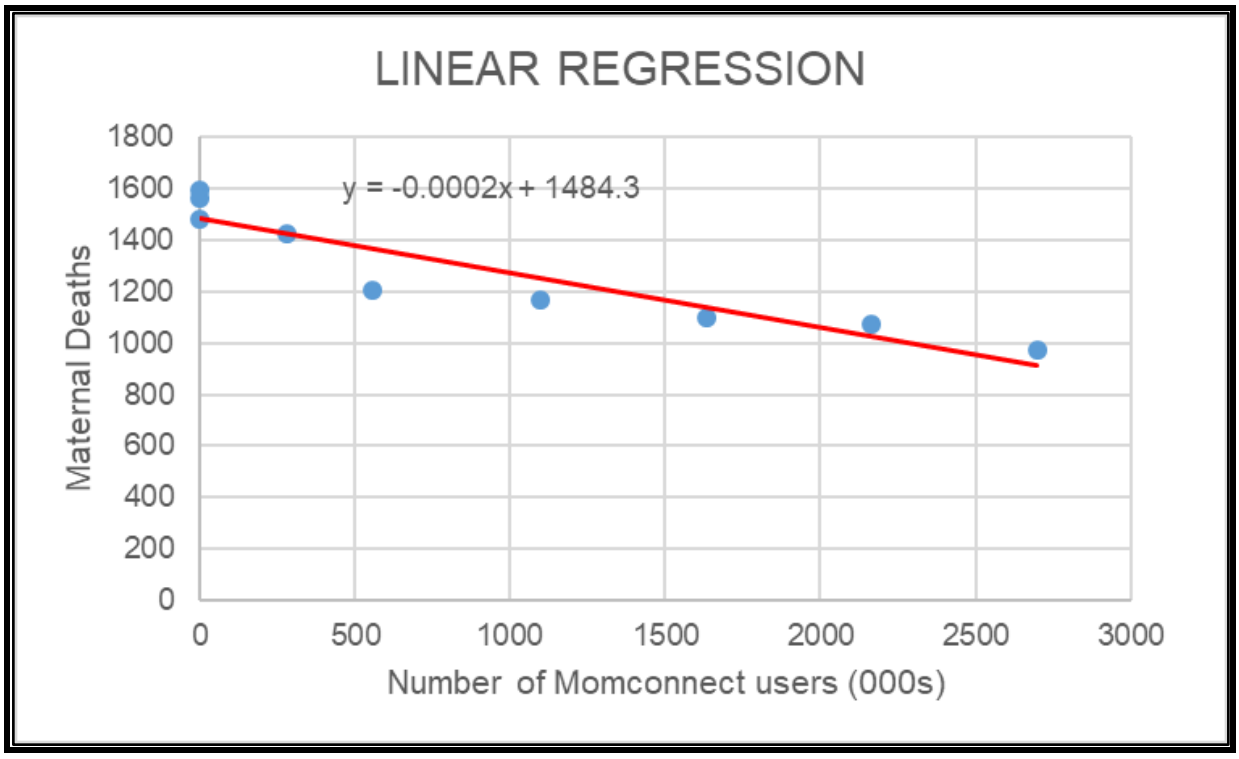


Figure 12: Regression line for Momconnect and Maternal Deaths

Figure 12 illustrates the data used in the regression test. The y-axis is the number of maternal deaths in South Africa (the dependent variable) and the x-axis is the total Momconnect subscribers. Each dot represents one year's data. How many maternal deaths in that year and how many Momconnect subscribers in the same year.

The red line running through the data dots, is called the regression line and it's drawn to show the line that best fits the data. In other words, the red line is the best explanation of the relationship between the independent variable and dependent variable.

3.7.3 REGRESSION TEST 2

- Dependent variable (y) – Maternal Deaths in South Africa from 2011 to 2019
- Independent variable (x) – Number of subscriber/users of Mum and Baby from 2011 to 2019

Null Hypothesis = 0. Meaning a change in the number of Mum and Baby users has no significant change to the number of maternal deaths and therefore no change to the MMR.

Alternative Hypothesis means that a change in the number of Mum and Baby users has a significant change to the number of maternal deaths and therefore a change to the MMR.

Refer to Annexure 2 for the detailed regression test and summary

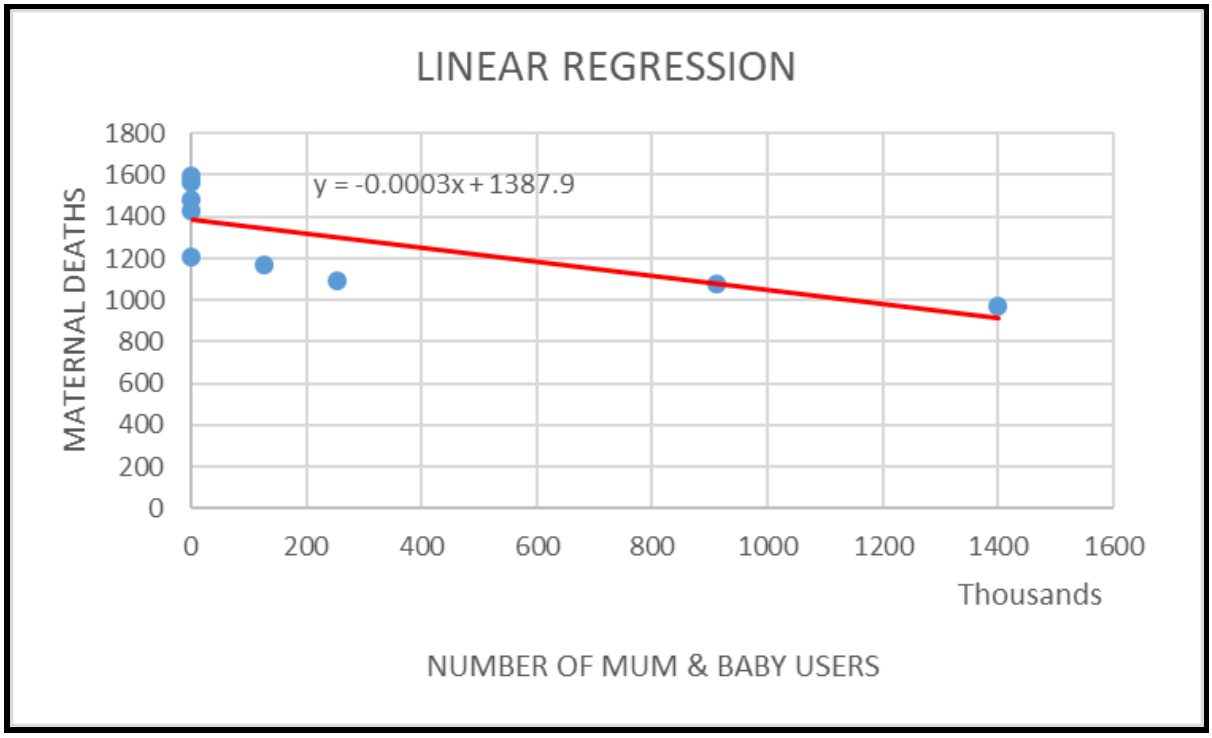


Figure 13: Regression line for Mum & Baby and Maternal Deaths

Figure 13 illustrates the data used in the regression test. The y-axis is the number of maternal deaths in South Africa (the dependent variable) and the x-axis is the total Mum & Baby subscribers. Each dot represents one year's data. How many maternal deaths in that year and how many Mum and Baby subscribers in the same year.

3.7.4 REGRESSION TEST 3

- Dependent variable (y) – Maternal Deaths in South Africa from 2011 to 2019
- Independent variable (x) – Total number of subscriber/users of mobile healthcare application from 2011 to 2019

Null Hypothesis = 0. Meaning a change in the total number of mobile healthcare application users has no significant change to the number of maternal deaths and therefore, no change to the MMR.

Alternative Hypothesis means that a change in the total number of mobile healthcare application users has a significant change to the number of maternal deaths and therefore a change to the MMR

Refer to Annexure 3 for the detailed regression test and summary.

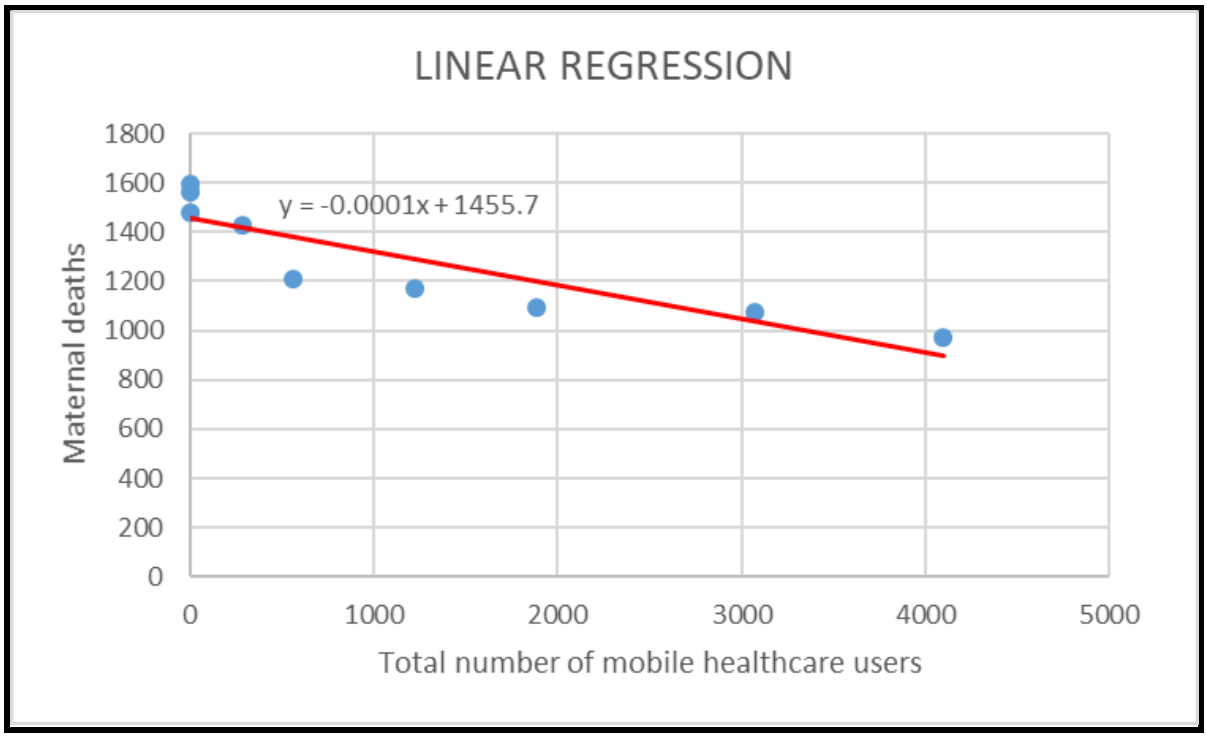


Figure 14: Regression line for total mobile healthcare application users and Maternal Deaths

Figure 14 illustrates the data used in the regression test. The y-axis is the number of maternal deaths in South Africa (the dependent variable) and the x-axis is the total mobile healthcare application subscribers. Each dot represents one year's data. How many maternal deaths in that year and how many mobile healthcare application subscribers in the same year.

3.8 LIMITATIONS OF THE STUDY

- The population for Mum & Baby is smaller than Momconnect, because of the difference in the launch date. Momconnect launched in 2014, and Mum & Baby launched in 2016.
- The population for maternal deaths are recorded from deaths that have been registered as deaths from maternal causes. The data will exclude deaths that are recorded as other reasons.
- The population for live births are births that have been recorded in the year of birth. Births that are not registered are not recorded and are therefore excluded from the population.

3.9 ETHICAL CONSIDERATIONS

This paper does not share any patient personal information and data that is used is from public sources. There is no disclosure of any intellectual property information or patent infringement.

3.10 RELIABILITY AND VALIDITY

The population samples are from census reports, national and international databases and therefore offers a large number of participants. The sample size for Mum and Baby and Momconnect population is large, with a subscriber base of over one million users for both programmes. The research methodology and design can be used to study the same questions in other countries or to narrow the study down to a regional study of the same factors (transferability) and variables. The scalar variable is time for all variables in this research.

CHAPTER 4: RESEARCH FINDINGS AND ANALYSIS

This chapter has three sections. The first will recap the research question, and the second will discuss the research findings and analyse the findings and the third will summarize the research and the significance of the research.

4.1 INTRODUCTION

To recap the research question is, does mobile technology innovation have an impact on the maternal mortality ratio in South Africa?

The null hypothesis is that the uptake of mobile healthcare applications has no change to the MMR in South Africa.

The research report examined the uptake of two mobile healthcare applications, Momconnect and Mum and Baby, and determines whether a change in the uptake of the mobile healthcare applications has a change on the maternal mortality ratio in South Africa. The research examined the data and populations for correlation, the strength of the relationship between the variables, examined the fit of the regression line to the data and tested whether the null hypothesis should be accepted or rejected.

4.2 FINDINGS AND ANALYSIS

4.2.1 CORRELATION ANALYSIS

- A correlation test was done to determine the correlation coefficient, to establish the strength of the relationship between, mobile healthcare applications and the number of maternal deaths in South Africa, and also to establish whether the correlation between these variables was a positive or negative relationship.
- The correlation tests show that both Momconnect and Mum & Baby has a strong negative correlation coefficient (close to -1). Which infers the uptake or diffusion of mobile healthcare applications increases, MMR for South Africa decreases.

4.2.2 REGRESSION ANALYSIS – MOMCONNECT AND MATERNAL DEATHS

- The Coefficient of Determination (R Square), of 0,86 (rounded to 2 digits), means that 86% of the values fit the regression analysis model. 86% of the change to the number of maternal deaths is influenced by the uptake of the Momconnect mobile healthcare application. This is regarded statistically as a good indicator or fit.
- Significant F in the analysis presents a value of 0.0003 or 0%, which is less than α = 0.05 (5%), that means that there is 0% risk in rejecting the null hypothesis.
- A change in the diffusion of mobile healthcare application, Momconnect, effects a change on the number of maternal deaths in South Africa, which infers a change in the MMR for South Africa.
- The correlation test showed a negative relationship between the two variables, which infers that an increase in the uptake of the number of Momconnect users, will

result in a decrease in the number of maternal deaths and therefore reduce the MMR in South Africa.

4.2.3 REGRESSION ANALYSIS – MUM & BABY AND MATERNAL DEATHS

- The Coefficient of Determination (R Square), of 0,55 (rounded to 2 digits), means that 55% of the values fit the regression analysis model. 55% of the change to the number of maternal deaths can be influenced by the uptake of the Mum and Baby mobile healthcare application. This is a positive fit; however, it is significantly lower than the fit than was shown by the Momconnect mobile healthcare application. Statistically, this is regarded as a moderate fit. This could be a result discussed earlier in this paper of the high diffusion and steeper adoption rate that Momconnect has. Mum and Baby are also second in the market to Momconnect. Although the content is diversified between USSD and mobisite, Momconnect had greater diffusion through the antenatal clinics and healthcare workers at the clinics.
- Significant F in the analysis presents a value of 0.02 or 2%, which is still less than $\alpha = 0.05$ (5%); however, the value is not significantly less than alpha. There is a 2% risk in rejecting the null hypothesis. The null hypothesis is, therefore rejected, which means a change in the diffusion of mobile healthcare application, Mum & Baby, effects a change on the number of maternal deaths in South Africa, which infers a change in the MMR for South Africa.
- The correlation test showed a negative relationship between the two variables, which infers that an increase in the uptake of the number of Mum and Baby users, will result in a decrease in the number of maternal deaths and therefore reduce the MMR in South Africa. The possible reasons for why a change in the diffusion of Mum and Baby, is not as significant as Momconnect as discussed later in this chapter.

4.2.4 REGRESSION ANALYSIS – MOBILE HEALTHCARE APPLICATIONS COMBINED AND MATERNAL DEATHS

- The Coefficient of Determination (R Square), of 0,78 (rounded to 2 digits), means that 78% of the values fit the regression analysis model. The uptake of mobile healthcare application can influence 78 % of the change to the number of maternal deaths. This is a positive fit. Statistically, this is regarded as a good fit.
- Significant F in the analysis presents a value of 0.001 or 0%, which is significantly less than $\alpha = 0.05$ (5%). There is a 0% risk in rejecting the null hypothesis. The null

hypothesis is rejected. This means that a change in the diffusion of mobile healthcare applications affects a significant change in the number of maternal deaths in South Africa, which infers a change in the MMR for South Africa.

- The correlation test showed a negative relationship between the two variables, which infers that an increase in the uptake of the number of mobile healthcare application users, will result in a decrease in the number of maternal deaths and therefore reduce the MMR in South Africa.

4.3 SUMMARY OF RESEARCH FINDINGS

The correlation between the variables being studied, mobile technology and MMR are negative. Meaning the increased diffusion of mobile technology will decrease the number of maternal deaths and therefore decrease the MMR in South Africa. The finding of the research report rejects the null hypothesis that mobile technology has no change to MMR in South Africa.

The findings of the research is significant for South Africa because the maternal mortality is widely acknowledged as a general indicator of the overall health of a population, of the status of women in society, and of the functioning of the health system. High maternal mortality ratios are thus markers of broader problems of health status, gender inequalities, and health services in a country. (World Health Organisation, Reproductive Health Indicators Guidelines for their generation, interpretation and analysis for global monitoring., 2006) MMR is also a measure for the Sustainable Development Goals (SDGs) and has a target for all countries to have a maximum MMR of 70 maternal deaths per 100000 live births. Solutions that can, therefore, decrease the MMR are of importance. The research findings infer that the diffusion of mobile technology using mobile healthcare applications is a factor, which can decrease maternal deaths and therefore decrease the MMR for South Africa. Mobile technology presents the five attributes needed for diffusion, (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, and (5) observability. (Rogers E. , 2003). The diffusion will allow scalability and create access to preventative healthcare information where it is limited, or no access to health facilitates or health workers. Mobile technology in South Africa has reached scale. It is an effective cost-efficient way to get information to parts of the population that have little or no access to healthcare workers or facilities. According to GSMA, South Africa is classified as a Fast Grower market in Southern Africa with five mobile operators with total mobile connections of 103,9 million, covering a population of 58,9 million, a SIM penetration of

176%. (GSMA, 2020) The mobile industry drives impact through the provision of and investment in high-performing mobile networks, which provide the foundations for the digital economy and act as a catalyst for a diverse and innovative range of services. In 2017, 3G coverage reached almost 90% of the world's population, while a 4G network covered more than 70% of the global population. (GSMA Intelligence, 2018 Mobile Industry Impact Report Sustainable Development Goals, 2018) With this growth in connectivity, individuals are increasingly using mobile to access an array of life-enhancing services that contribute to and catalyse the achievement of the UN Sustainable Development Goals (SDGs). (GSMA Intelligence, The Mobile Economy 2020, 2020)

The analysis in the research is significant because it discusses the impact that mobile healthcare applications have on maternal healthcare in South Africa, and means that women can start becoming an active part of the country. In turn, this will have positive socio-economic benefits. Access to a mobile device with a healthcare application means that the user will be able to get the right information, at the right time, in the right format. For example, an illiterate Nigerian woman in her first trimester of pregnancy might receive a voice message in the Hausa language describing anaemia and explaining how to get iron supplements. The same system can remind her when she needs to go for a prenatal visit or take her children for immunisation. Eventually, she will be able to use her mobile phone for a video consultation with a doctor when non-routine problems arise. With the doctor's guidance, she will be able to use her mobile phone to check her temperature, blood pressure and other vital signs to assist with her diagnosis. (Franklin, 2018)

The next chapter will conclude and make recommendations based on the research finding that the variable of mobile technology, has a change in the number of maternal deaths in South Africa.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

People in Africa and throughout low and middle-income countries are seizing the opportunities that technology provides, using mobile phones for everything from making payments to issuing birth certificates, to gaining access to health care. Technology is an enabler for the innovation of healthcare delivery; there are countless ways in which technology can be deployed to improve health-care access and delivery. (Aerts, 2017)

This research report examined the variables of the diffusion of two mobile healthcare applications, Momconnect and Mum & Baby. It determined whether the diffusion of these two mobile healthcare applications have a change to the maternal mortality ratio (MMR) in South Africa.

The findings of this report infer that the independent variable of mobile technology, through its characteristics of diffusion, can be used as a tool to scale mobile healthcare applications to change the number of maternal deaths and decrease MMR in South Africa.

Modern business is, to a very considerable extent, the creature of technology. Modern industry was born when the new technology of power generation forced manufacturing activities out of home and workshop and under the one roof of the modern “factory,” beginning with the textile industry in eighteenth-century Britain. Furthermore, the large business enterprise of today has its roots in the first “big business,” the large railroad of the themed-nineteenth century, that is, in technological innovation. Since then, the “growth industries,” down to computer and pharmaceutical companies of today, have primarily been the outgrowth of new technology. (Drucker, 1981)

A 2009 global survey conducted by the World Health Organization (WHO) in 114 member states found that 83% of the member states were implementing mHealth services. The mHealth services fell into 14 distinct categories: health call centers, emergency toll-free telephone services, managing emergencies and disasters, mobile telemedicine, appointment reminders, community mobilization and health promotion, treatment compliance, mobile patient records, information access, patient monitoring, health surveys and data collection, surveillance, health awareness-raising, and decision support systems. (Africa Strategies for Health, 2016)

One of the most promising aspects of mHealth is its potential for enhancing the smart integration of health services and the continuity of care across provider, place, and time by making information available at the right place and the right time. Strengthening patient management and health systems in this fashion can only be achieved if the various mHealth and HIS platforms have sufficient common ground to reliably exchange messages in a way that minimizes errors and misunderstandings. Known as interoperability, this ability of diverse systems and organizations to communicate and work together (interoperate) requires the establishment of and adherence to standards. Much like speaking a common language enables communication, using common standards for how data is structured and exchanged enables mHealth platforms and HIS to share data. mHealth interventions are significantly more powerful when health sector actors make their information systems interoperable. Through close cooperation,

governments, donors, and private health care providers can achieve interoperability by applying the same standards. These actions will maximize the power of mHealth as a tool for coordinating individual, patient-level services and public health programs. (Africa Strategies for Health, 2016)

5.2 RECOMMENDATIONS AND SUGGESTIONS

As markets develop, different types of customers with different motivations emerge and innovation efforts must adapt accordingly. The way innovations diffuse through a population or markets depends strongly on the characteristics of the innovation itself and the adopters or customers. (Goffin & Mitchell, 2017) Mobile technology addresses challenges in the delivery of basic health services to underserved populations, by successfully addressing challenges such as reducing maternal and infant mortality rates, combatting infectious diseases, creating awareness of HIV and delivering nutritional health and treatment for a variety of health conditions remotely. (GMSA, The Mobile Economy 2015, 2015)

The focus of innovation changes as the underlying technologies mature. The emergence of a dominant design marks a point when competition shifts away from the core attribute towards other factors such as quality and services. (Goffin & Mitchell, 2017) This is evident in the evolution of both the Mum & Baby and Momconnect mobile healthcare applications. Momconnect has introduced WhatsApp messaging, which allows the cost-saving for the government but also allows the service to engage with users with richer content that can be delivered over the app. The SMS content is being expanded to include HIV-related messages and other high-risk health issues during pregnancy such as gestational diabetes, anaemia and hypertension. It is being extended up to a child's fifth birthday. Educating users on these health issues will lead to a greater health impact. (United Nations Foundation) Mum & Baby launched the premium subscription, which serves richer media such as video tutorials and healthcare tools, like the medicine checker and immunisation calendar. Based on the service usage data, the most accessed tool for all mobisite subscribers is the immunisation calendar, followed by the due date calculator. The Mum & Baby service also offers health information on 24 different health topics that can be accessed through articles and tutorials. The health topic most accessed by mothers was information on teething. (KPMG, 2019) Examples of how the content can be diversified and the adoption rate increased by service a broader customer need can be seen in examples like Kasha. Mobile technology is helping women across Sub-Saharan Africa to access the internet,

broaden their learning and, in turn, improve the wellbeing of their families. For example, Kasha is an e-commerce platform in Rwanda that sells health and personal care products, such as contraceptives and tampons. Customers can access Kasha via USSD or a mobile or web app. (GSMA Intelligence, The Mobile Economy Sub Saharan Africa 2019, 2019)

Diffusion is a very social process that involves interpersonal communication relationships. Thus interpersonal channels are more powerful to create or change strong attitudes by an individual. Change agents often play an important role in innovation diffusion. A change agent is an individual who influences clients' innovation decisions in a direction deemed desirable by a change agency. Change agents who want to promote a new idea or technology must pay attention to those individuals whose words and behaviours influence that of their peers. Opinion leaders are key actors in the diffusion of innovations. Opinion leaders have greater exposure to new ideas through the media by having more exposure to change agents. They have been a key vector of diffusion for many medical and information technologies, and a large amount of effort is dedicated to identifying, informing and convincing them to become early adopters. (Cain & Mittman, 2002) The most important lesson is that to ensure scalability and sustainability, there has to be political support and leadership. The Minister of Health champions Momconnect, it is automatically given an endorsement by many stakeholders, who would otherwise not give their active support, including managers in the national and provincial DOHs. Having a senior manager in the DOH responsible for leading the implementation also gives Momconnect the necessary authority to attract support from a range of stakeholders. Local innovations are adopted for national scale-up. For example, one province introduced a sticker which is placed on the outside of the woman's antenatal folder. This bright sticker indicates that the woman is registered on Momconnect and serves a dual purpose. In essence, other women are stimulated to get a sticker, and health workers immediately have another chance to motivate the women without stickers to register on Momconnect. (Africa Strategies for Health, 2016)

The scale is key to diffusion on technological innovations that are required to have a broad social benefit. The opportunity to expand the platform for a more inclusive role around preventative health for all members of the family, especially the elderly that are in rural areas and have no access to healthcare information. Enabling services and relevant content: mobile technology has enabled a range of life-enhancing services such as mobile financial services, mobile agriculture and mobile health. By the end of 2018, there were 866 million registered mobile money accounts worldwide, helping to expand financial and social inclusion. Meanwhile, emerging areas such as IoT, big data

and artificial intelligence are demonstrating their potential for transformative impacts on lives. (The Mobile Economy 2019., 2019) An example of this is Nigerian tech start-up Ubenwa (meaning “cry of a baby” in the Igbo language) who has developed a machine learning system to detect child birth asphyxia. The AI solution has achieved over 95% accuracy in trials with pre-recorded baby cries and has the potential to help save lives through early detection and treatment. (GSMA Intelligence, The Mobile Economy Sub Saharan Africa 2019, 2019)

Mum & Baby have introduced a premium offering to access a paying audience; this increases that rate of diffusion and allows investment in more valuable content. The monetisation strategy also subsidizes the cost of free content, improvements on the current service and the cost of mobile data. The opportunity is coined the wellness opportunity. Several strong macro-level trends are driving the development of digital health services, including population ageing, rising healthcare costs and limited clinician resources. In the healthcare sector, there is also a broad shift towards value-based care, personalised medicine and the “consumerisation of healthcare”. Moreover, several specific characteristics differentiate the digital consumer health and wellness market from the broader market for digital services:

- Speed of growth
- Diversity of players
- Potential for social and gamification

An overlap between the consumer sector and a vertical sector – in this case, healthcare, wellness is just one part of a much broader digital healthcare opportunity. However, it is one of the most accessible parts of the market for new entrants with strong consumer brands and access to relevant data. (Rehak & Pringle, 2016)

Consumerism in healthcare opens new opportunities for mobile carriers from two perspectives. First, carriers can leverage this trend to experiment with new direct-to-consumer services in the health and wellness space. Second, carriers can leverage their experience selling to consumers and managing consumer relationships to build partnerships with healthcare players with little to no expertise in a consumer-centric market. (Kent, 2014)

Its integration highly influences Momconnect’s diffusion into the National Healthcare System. The platform makes use of the “big data” technology and captures, stores and sends vital patient information to anywhere at any time. This will assist in the cases of emergencies where many women are still losing their lives in childbirth. An example of how Momconnect’s spin-off mobile application Nurse Connect can improve the mobile application is Kenyan start-up Nurse in Hand. Nurse in Hand collects and delivers

information to a network of paramedics to improve emergency response times. In March 2018, it partnered with Apla Tech Company to build a blockchain-based accident response platform, to reduce the distance between first responders in Emergency Care Centres and accident victims. The use of mobile networks generates vast amounts of data about people's geographic location, calling and messaging behaviour. This mobile 'big data' – when aggregated, anonymised and analysed – can provide valuable and actionable insights across a wide variety of use cases. While the majority of mobile big data implementations are commercial use cases and research, pilot projects have demonstrated that qualities of mobile big data, such as frequency and high penetration rate, can add value when addressing environmental, social and governance (ESG) challenges. From tackling environmental issues and tracking disease outbreaks to improving urban planning and responding to disasters.

Mobile Valued Added Services (mVAS), like, (1) maternal, new-born and child health (MNCH) messaging; (2) health hotlines; (3) health insurance which can be purchased using mobile phone credits and (4) mobile money is of interest to consumers, although consumers have the best appreciation of health hotlines. Figure 19 illustrates that consumers' best appreciate the benefits of health hotlines among all the mVAS offerings. "Being able to consult with a doctor anytime, anywhere at an affordable price" sums up the key benefits that consumer's value. Interest in MNCH messaging is slightly lower than the interest in health hotlines. While 44% of the women are willing to pay some amount for health hotlines, the figure is only 37% for MNCH messaging. The comment "to be advised by someone who does not care and cannot be seen" best describes partial dislike towards MNCH messaging. The bundling of MNCH messaging and a health hotline increases BoP consumers' willingness to pay by 9% points from 38% to 47% for the bundled service. (GSM Association, Understanding the needs of pregnant women in South Africa,, 2014)

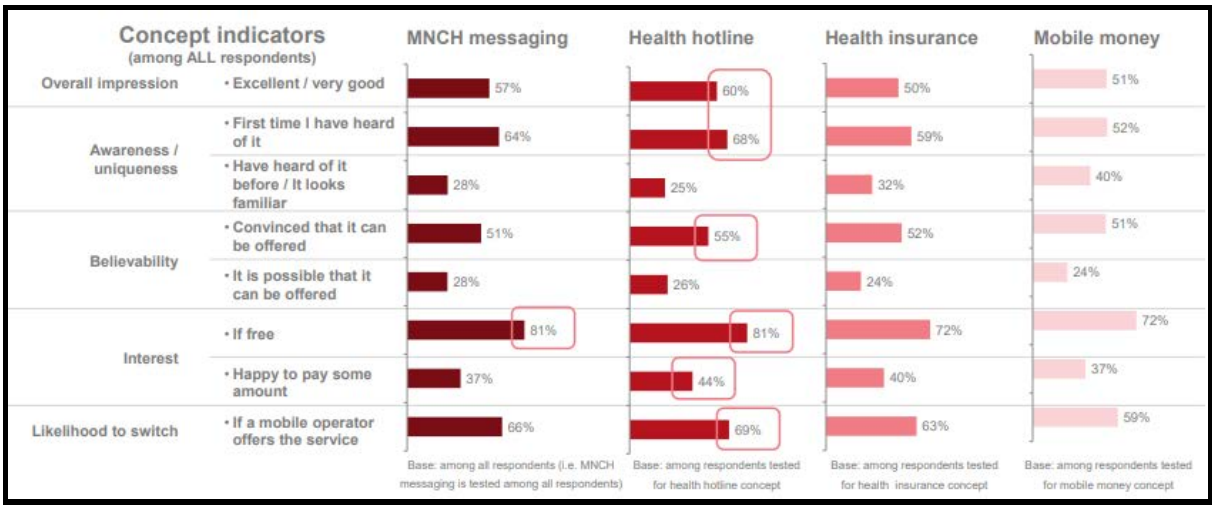


Figure 15 Comparison of the interest mVAS offerings for consumers *(GSM Association, Understanding the needs of pregnant women in South Africa,, 2014)*

Mobile connectivity continues to transform the lives of millions of people across the region, by enabling the delivery of life-enhancing services, including education, health and financial inclusion. This is especially significant given the challenge of providing services by conventional means amid considerable infrastructure and funding gaps. (GSMA Intelligence, The Mobile Economy Sub Saharan Africa 2019, 2019)

5.3 SUGGESTIONS FOR FUTURE RESEARCH

Maternal mortality is both multi-dimensional health and broader developmental challenge. Improved sexual and reproductive health is also dependent on a range of other factors including education, decent work, safety, clean water and sanitation, and adequate transport facilities. (Improve maternal health Where are we?., n.d). Mobile healthcare can have other socio-economic benefits in areas of wellbeing, an example of this is, using solutions such as remote patient monitoring, patients can reduce the number of trips to see a medical provider, saving time and reducing fuel usage and hospital emissions. In 2018, Verizon avoided 147,023 tonnes of CO2e through remote patient monitoring and reduced travel and days in the hospital. (GSMA Intelligence, The Mobile Economy 2020, 2020)

This research report examines the diffusion of mobile technology and its causal effect of maternal mortality ratio (MMR) in South Africa. Further research can be done to examine how the diffusion of mobile technology can extend to other healthcare challenges in South Africa.

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ANNEXURE 1

Regression analysis and summary output for the variable (y) Momconnect and variable (x) Maternal Deaths in South Africa

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.92959919							
R Square	0.864154655							
Adjusted R Square	0.844748177							
Standard Error	91.07827776							
Observations	9							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	369380.8454	369380.8454	44.52918551	0.000284415			
Residual	7	58066.76876	8295.25268					
Total	8	427447.6142						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1484.347457	42.3687161	35.03404382	4.00552E-09	1384.161363	1584.53355	1384.161363	1584.53355
MOMCONNECT SUBSCRIBERS/USERS	-0.000210462	3.15393E-05	-6.67301922	0.000284415	-0.000285041	-0.000135884	-0.000285041	-0.000135884
RESIDUAL OUTPUT								
Observation	*Predicted MATERNAL DEATHS*	*Residuals*						
1	1484.347457	108.5130434						
2	1484.347457	80.30710344						
3	1484.347457	-4.574606559						
4	1425.561953	0.482246945						
5	1366.77645	-159.0251996						
6	1253.714661	-84.47774091						
7	1140.652872	-44.70333227						
8	1028.375983	47.07509655						
9	916.0990946	56.40338891						

Figure 16 Regression analysis and summary output for the variable (y) Momconnect and variable (x) Maternal Deaths in South Africa

ANNEXURE 2

Regression analysis and summary output for the variable (y) Mum & Baby and variable (x) Maternal Deaths in South Africa

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.74125751							
R Square	0.549462696							
Adjusted R Square	0.485100224							
Standard Error	165.8661663							
Observations	9							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	234866.5183	234866.5183	8.537004219	0.022282353			
Residual	7	192581.0959	27511.58513					
Total	8	427447.6142						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1387.915224	65.16549574	21.29831451	1.26667E-07	1233.823312	1542.007135	1233.823312	1542.007135
MUM & BABY SUBSCRIBERS/USERS	-0.000337263	0.000115429	-2.921815227	0.022282353	-0.000610209	-6.43161E-05	-0.000610209	-6.43161E-05
RESIDUAL OUTPUT								
Observation	*Predicted MATERNAL DEATHS*	*Residuals*						
1	1387.915224	204.9452762						
2	1387.915224	176.7393362						
3	1387.915224	91.85762621						
4	1387.915224	38.12897621						
5	1387.915224	-180.1639738						
6	1345.302102	-176.0651823						
7	1302.688981	-206.7394408						
8	1080.908509	-5.457429208						
9	915.7476723	56.75481121						

Figure 17 Regression analysis and summary output for the variable (y) Mum & Baby and variable (x) Maternal Deaths in South Africa

ANNEXURE 3

Regression analysis for total mobile healthcare application users and Maternal Deaths

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.88451676							
R Square	0.782369899							
Adjusted R Square	0.751279885							
Standard Error	115.2794538							
Observations	9							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	334422.1469	334422.1469	25.1646683	0.001536589			
Residual	7	93025.46729	13289.35247					
Total	8	427447.6142						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1455.726648	51.0496657	28.51588993	1.6772E-08	1335.013371	1576.439926	1335.013371	1576.439926
TOTAL NUMBER OF MOBILE HEALTHCARE APPLICATION SUBSCRIBERS/USERS	-0.000136416	2.71938E-05	-5.016439804	0.001536589	-0.000200719	-7.2113E-05	-0.000200719	-7.2113E-05
RESIDUAL OUTPUT								
Observation	*Predicted MATERNAL DEATHS*	*Residuals*						
1	1455.726648	137.1338519						
2	1455.726648	108.9279119						
3	1455.726648	24.04620187						
4	1417.623403	8.420796503						
5	1379.520159	-171.7689089						
6	1289.000234	-119.7633138						
7	1198.480309	-102.5307687						
8	1035.99936	39.45171967						
9	896.4199741	76.08250949						

Figure 18: Regression analysis for total mobile healthcare application users and Maternal Deaths

C2 General C2 General

ANNEXURE 4

RESEARCH FRAMEWORK

1. THEORY

The Diffusion of Innovation Theory

2. HYPOTHESIS

Null Hypothesis = The use of mobile technology healthcare applications has no impact on the Maternal Mortality Rate (MMR) in South Africa

3. RESEARCH DESIGN

Using data from the mobile healthcare application programmes Momconnect and Mom & Baby, a quantitative study was used for this research paper.

4. DEVISE MEASURES OF CONCEPTS

Independent variables

Numbers of mobile healthcare application users in South Africa

Number of healthcare professionals

Dependent variable

The Maternal Mortality Rate in South Africa

5. SELECT RESEARCH SITE

The research focuses on the impact Momconnect and Mum & Baby mobile healthcare applications has on MMR in South Africa

6. SELECT RESEARCH SUBJECTS

Momconnect subscribers

Mum & Baby subscribers

Number of professional healthcare providers

7. ADMINISTER RESEARCH INSTRUMENTS/COLLECT DATA

Data from public data bases

Subscriber data for Momconnect and Mum & Baby

8. PROCESS DATA

Regression testing was used to determine the strength on the relationship between the dependent variable (MMR) and independent variables (Momconnect subscribers, Mum & Baby subscribers and number of healthcare professionals in South Africa.

T-test, was used to test the null hypothesis

9. ANALYSE DATA

The data from the regression test was used to understand and explain the relationship between mobile healthcare applications and the impact of these applications on MMR in South Africa.

10. FINDINGS/CONCLUSIONS

The research findings are to establish whether mobile healthcare applications/technology has an impact on MMR in South Africa. The NULL hypothesis would therefore be false.

Figure 19 Summary of Research Framework

C2 General C2 General

ANNEXURE 5

MUM & BABY SERVICE LOGIC MODEL

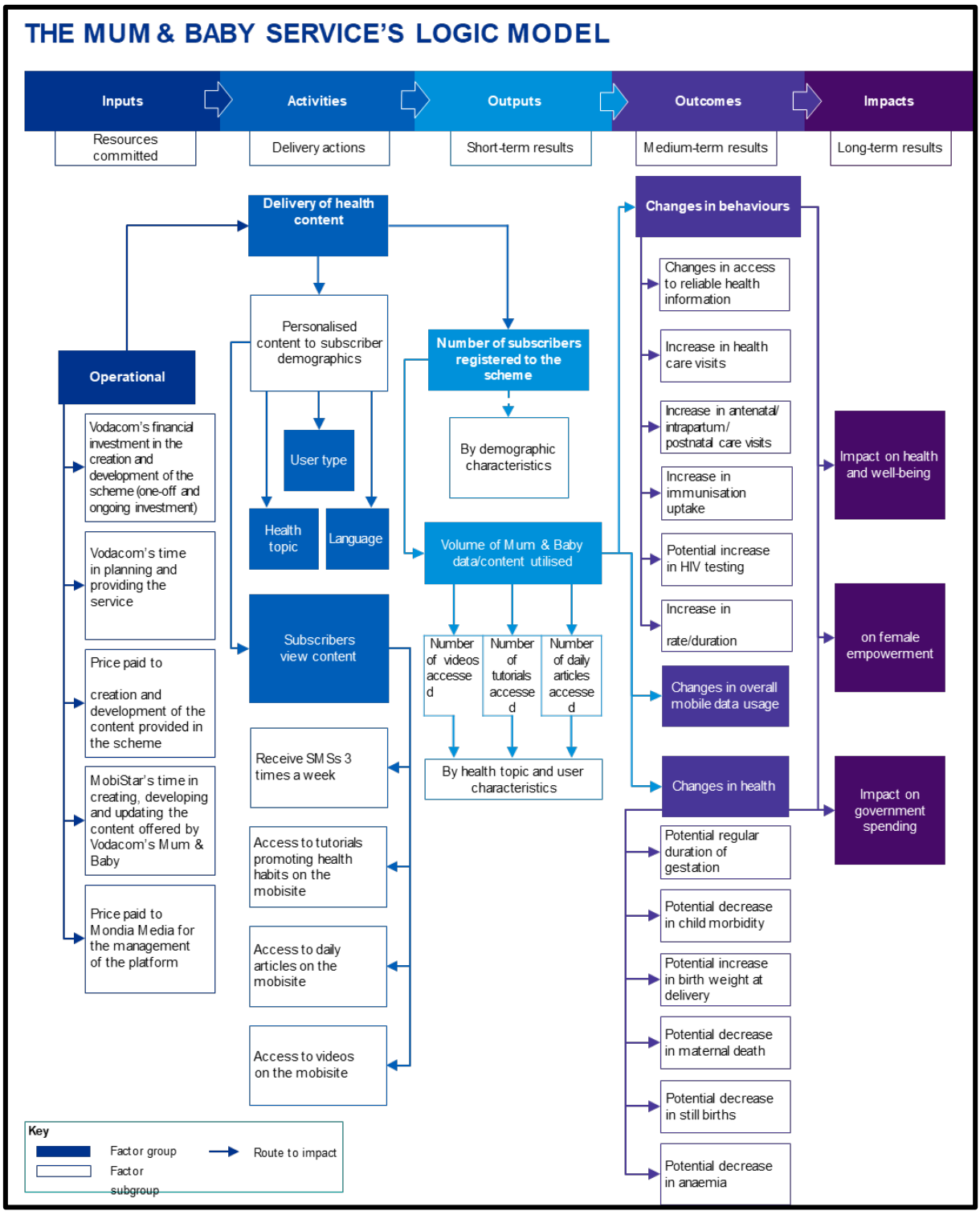


Figure 20 Mum & Baby Service Logic Model