DETERMINING THE FEASIBILITY OF USING MOBILE PHONES TO STRENGTHEN THE INFORMATION MANAGEMENT OF PREVENTATIVE HEALTH CARE IN SOUTH AFRICA

By

Frans Johannes Snyders

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Study leader: Ms Liezl van Dyk

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DECLARATION

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ABSTRACT

South Africa's health sector has not yet shown enough improvement to reach the Millennium Development Goals related to health. One of the problem areas is the low infant and child vaccination coverage in certain areas of South Africa. The use of mobile phones in health care (mHealth) has the potential to strengthen the primary health care system through improved information management. A mobile health solution for vaccination (MHSV) can be used to improve information management of vaccinations, which in turn can improve vaccination coverage. However, the feasibility of implementing such an MHSV in the South African context is unknown.

This study therefore investigates the feasibility of using mobile phones to improve information management for child vaccinations in South Africa. Feasibility is determined by using a feasibility framework together with business model development.

The feasibility framework, which is informed by a literature study, surveys and a case study, determines the feasibility of an MHSV in terms of human factors, technical feasibility, information management, policies and ethics, and economics. It is found that an MHSV is feasible in South Africa, although certain areas pose challenges that will have to be considered.

Complementing the feasibility framework, business models are developed to suggest possible ways in which an MHSV can be deployed in South Africa. These models build on the results from the feasibility framework and are developed using Osterwalder's business model canvas. The effect of the National Health Insurance (NHI) on these business models is also examined.

In order to validate the feasibility framework and business models, interviews were held with experts in health care and mobile phone solutions. These interviews show that the research is valid and that the feasibility framework and business models can be generalised to the wider field of mHealth solutions.

OPSOMMING

Suid-Afrika se gesondheidsektor het nog nie genoeg verbetering getoon om die gesondheidsverwante Millenium Ontwikkelingsdoelwitte te bereik nie. Een van die probleemareas is die besondere lae inentingsdekking van babas en kinders in sekere gebiede van Suid-Afrika. Die gebruik van selfone vir gesondheidsorg hou die potensiaal in om die primêre gesondheidsorgstelsel te versterk deur inligtingsbestuur te verbeter. 'n Inentingsoplossing wat gebruik maak van selfone, bekend as 'n "mobile health solution for vaccination" (MHSV), kan inligtingsbestuur van inentings verbeter, wat hoër inentingsdekking tot gevolg kan hê. Die haalbaarheid van die implementering van so 'n MHSV in die konteks van Suid-Afrika is egter onbekend.

Hierdie studie ondersoek dus die haalbaarheid daarvan om selfone te gebruik vir beter inligtingsbestuur van kinder-inenting in Suid-Afrika. Haalbaarheid word vasgestel deur 'n haalbaarheidsraamwerk en die ontwikkeling van besigheidsmodelle te gebruik.

Die haalbaarheidsraamwerk, wat toegelig word deur 'n literatuurstudie, vraelyste en 'n gevallestudie, bepaal die haalbaarheid van 'n MHSV in terme van menslike faktore, tegniese haalbaarheid, inligtingbestuur, beleid en etiek, en ekonomie. Daar word gevind dat 'n MHSV haalbaar is in Suid-Afrika, alhoewel sekere areas uitdagings inhou.

Die haalbaarheidsraamwerk word aangevul deur die ontwikkeling van besigheidsmodelle wat moontlike maniere voorstel waarop 'n MHSV in Suid-Afrika ontplooi kan word. Hierdie modelle word geskoei op die resultate van die haalbaarheidsraamwerk en word ontwikkel met behulp van Osterwalder se besigheidsmodelskema ("business model canvas"). Die effek van die nasionale gesondheidversekering op hierdie modelle word ook ondersoek.

Onderhoude met kundiges in die veld van selfoonoplossings vir gesondheidsorg word gebruik om die haalbaarheidsraamwerk en die besigheidsmodelle te valideer. Die onderhoude toon dat die navorsing geldig is en dat die haalbaarheidsraamwerk en besigheidsmodelle veralgemeen kan word na die wyer veld van selfoonoplossings vir gesondheidsorg.

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GLOSSARY

AIDS – Acquired Immunodeficiency Syndrome

API – Application Protocol Interface

Apps – Mobile device applications

BoP – Base of Pyramid

Cell phone – Mobile phone as referred to in South Africa

CHW – Community Health Worker

CMS – Council of Medical Schemes or Content Management System

DHIS – District Health Information System

DOH – Department of Health

DSL – Domain Specific Language

DTP – Diphtheria Tetanus acellular Pertussis (Inactivated Polio vaccine)

EHR – Electronic Health Record

EPI – Expanded Program on Immunization

ERD – Entity Relationship Diagram

EMR – Electronic Medical Records

HaaS – Hardware as a Service

HIS – Health Information System

HISP – Health Information System Program

HIV – Human Immunodeficiency Virus

HL7 – Health Level 7

HPCSA – Health Professions Council of South Africa

IaaS – Infrastructure as a Service

ICD – International Classification of Diseases

ICT – Information and Communication Technology

ICT4H – ICT for Health

ICD-10 – International statistical Classification of Diseases and related health problems version 10

IDE – Integrated Development Environment

IP – Internet Protocol

ISO/TC 215 – International Organisation for Standardization's Technical Committee

IT - Information Technology

IVR – Interactive Voice Response

LMIC – Low and Middle Income Countries

MCWM – maternal, child and women's health

MDG – Millennium Development Goal

MHSV – Mobile Health Solution for Vaccination

MNO – Mobile network operator / mobile service provider

MRC – Medical Research Council

Mxit – An instant messaging application, popular in South Africa

NDOH - National Department of Health

NHI – National Health Insurance

NHIS/SA – National Health Information Systems Committee

NHC – National Health Council

NHC/MIS – National Health Care Management Information System

NSDA – Negotiated Service Delivery Agreement

ORT – Oral Rehydration Therapy

PaaS – Platform as a Service

PCV – Pneumococcal vac

PHC – Primary Health Care

PHISC – Private Health Information Standards Committee

PMTCT – Prevention of Mother To Child HIV Transmission

RoP – Rest of pyramid

S3 – Simple Storage Service

SaaS – Software as a Service

SMS –Text message or short message service, as referred to in South Africa

SWOT – Strengths Weaknesses Opportunities and Threats

TB – Tuberculosis

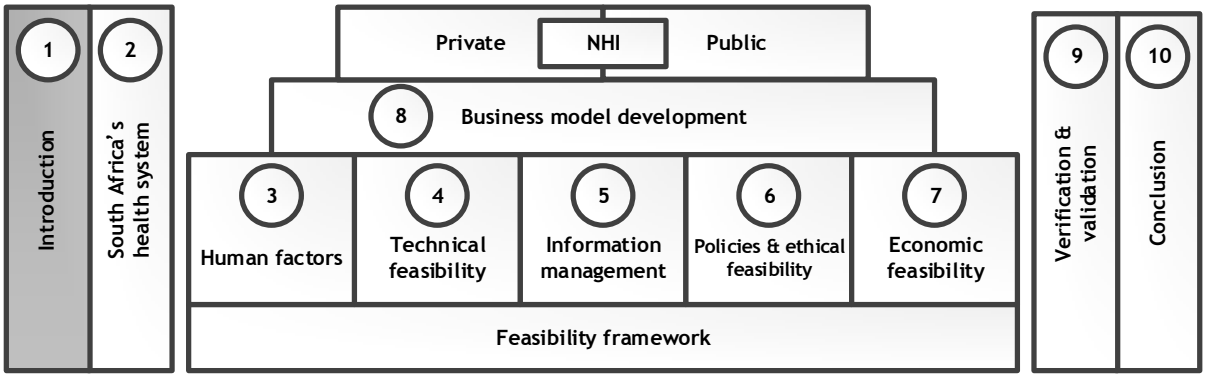
TCO – Total cost of ownership

UN – United Nations

USSD – Unstructured Supplementary Service Data

WHO – World Health Organization

CHAPTER 1 INTRODUCTION



The outcome of this chapter is to define the research design of this paper. First an overview is given of key health aspects in South Africa. The research basis is discussed followed by the methodology. Finally an outline of the chapters is given.

1.1 Study context

This study originated from the idea of using mobile phone technology to deliver and improve health care. The Pikinini project presented an opportunity to do a case study on a venture with this exact intent. The aim of the Pikinini project was to use mobile phones to provide caretakers with relevant health information of their child. As the project was developed, it provided a proof of concept for a mobile health solution for vaccination (MHSV) in the South African context. Due to lack of funding, however, Pikinini was never implemented, and the feasibility of implementing such a project in South Africa remained unknown.

When considering the feasibility of implementing a project such as Pikinini, a variety of areas have to be investigated. This study addresses this knowledge gap by developing a feasibility framework that evaluates different areas required for such a project to be feasible. With Pikinini, practical ways of turning the project into a venture was also lacking. To address this need, this study develops different business models that provide possible ways in which a project such as Pikinini can be deployed.

The purpose of this study is therefore to determine the feasibility of an MHSV in the South African context and to develop business models for such an MHSV. The accomplishment of this purpose will aid projects like Pikinini to help improve health care for children.

1.2 Health environment

First an overview is given in this section of key health aspects in South Africa. The importance of immunisation is that it reduces the future burden of disease on the health system by preventing serious child illness and child mortality [1]. The potential of mobile phones to strengthen health systems is widely published. When considering preventative health care in terms of immunisation, mobile phones can be used to improve information management of immunisation services.

1.2.1 *Vaccination statistics*

The health statistics for 2011/2012 was published by the Health Systems Trust [1] based on district health information system (DHIS) data. The immunisation indicator for 2011/2012 is shown in Table 1-1.

Table 1-1: Immunisation indicators from DHIS and population data [1]

Immunisation Indicator	National average	District high	District low	District difference
Immunisation coverage (under 1yr)	95.2%	125,0%	55,2%	69,8%
Measles 1st dose coverage (under 1yr)	100,9%	130%	75,1%	54,9%
Measles 1st to 2nd dose drop-out rate	15.4%	27,9%	2,0%	25,9%
Rotavirus 2nd dose coverage	98,2%	130,5%	58,1%	72,4%
Pneumococcal vac (PCV) 3rd dose coverage	94.1%	122%	58,9%	63,1%

Coverage was calculated by dividing data from the DHIS by population data. Refer to Table D-1 (APPENDIX D) for the standard immunisation schedule. From Table 1-1 it can be seen that even though national averages may be high, district averages can be low. Differences between districts can also be seen, highlighting inequalities in immunisation coverage. The coverage exceeding than 100% may be due to data quality issues or the inclusion of immunisation campaign data [1].

The quality of routine health data for prevention of mother to child HIV transmission (PMTCT) submitted to the DHIS was investigated by Mate *et al.* [2] in three districts of Kwazulu-Natal. It was found that 50% of data elements were incomplete and 87% of data elements were not accurate. This finding raises concerns about the quality of routinely collected data in the South African health system.

National vaccination coverage figures in South Africa has been contentious, with significantly different figures reported by national government (DOH) and organisations (WHO / UNICEF) [3]. Vaccination coverage is defined as the percentage of a target population that has been vaccinated. Eleven of the sixteen vaccination indicators from the DHIS reported more than 100% vaccination coverage between 2009 and 2011 [4]. Vaccination statistics for South Africa by WHO/UNICEF [5] report that vaccination coverage has decreased between 1990 and 2010.

While the DOH's method of collection can cause over-estimation, that of the WHO can cause under-estimation [3]. Regarding the discrepancy, Prof. Alex van der Heever commented that "no verifiable claim can be made about immunisation rates in SA" [6]. Even though under-reporting or over-reporting may explain the differences, a measles outbreak in 2009 [7] showed that routine vaccination coverage is not effective.

An additional concern is that high levels of vaccination coverage averages at provincial level can hide low vaccination coverage at the district level [8]. A study in the measles vaccination coverage [9] highlighted these inequalities with a 56% and 51% difference in coverage between regions for the first and second dose of measles vaccine respectively.

1.2.2 *Inequalities in health care*

The health sector of South Africa has been marked by inequalities in resource allocation due to historic reasons [10]. Unequal distribution of resources leads to unequal development and support of health care facilities in South Africa. A shortage of health care workers at the primary health care level, estimated at about 80 000 workers [11], further contributes to the continuation of inequalities.

Socioeconomic factors also play a role in the inequalities of health coverage even though basic health care in South Africa is free. In Table 1-2 health indicators for the poorest 20% of the population are compared with those of the richest 20%.

Table 1-2: Socioeconomic inequalities in health coverage [5]

Indicator	Poorest 20%	Richest 20%
4+ Antenatal care visits	15%	55%
ORT & continued feeding	40%	100%
Measles vaccination	15%	70%
DTP vaccination	10%	75%
Vitamin A supplement	20%	75%

An example of differences in health coverage among provinces can be seen in Table 1-3, which lists the percentages of women who receive post-natal care within 6 days of delivery in each province [12].

A study conducted in the Western Cape [13] found that only 39% of the facilities visited offer immunisation services on a daily basis, which is below the national average of 47%. However, acceptable levels of child health services, as reflected by the availability of baby weighing scales and adequate vaccines, was found. Vaccines and tuberculosis drugs were also available at all the clinics visited, which is above the national average of 97%.

Table 1-3: Percentage of women who receive post-natal care within 6 days of delivery in each province [12]

Province	Women receiving post-natal care within 6 days of delivery
Free State	80%
North West	76%
Limpopo	65%
Gauteng	65%
KwaZulu-Natal	56%
Eastern Cape	44%
Mpumalanga	40%
Northern Cape	38%
Western Cape	Does not report
Average	52%

All of the inequalities mentioned are evidence which shows that South Africa's health system faces many challenges in order to deliver equal health care to all. One of the DOH's initiatives to help address health care inequalities is the National Health Insurance (NHI), which will be further discussed in CHAPTER 6. The aim of the NHI is to enable all South Africans to receive quality health care [14]. However, it is yet to be implemented.

1.2.3 *Mobile phones for health care*

The use of mobile phones for health services and information, known as mHealth [15], can strengthen health care delivery by providing an additional interface for patients to access health care [11]. In this study, a health care solution or service that uses mobile phones specifically for vaccination purposes is referred to as a mobile health solution for vaccination (MHSV).

The following are examples of international projects concerning vaccination:

- Prioritised vaccination through real-time tracking of outbreaks in India [15]
- Improved patient outcomes for vaccination in Spain, Australia, Finland and Korea [15]
- EpiSurveyor: remote data collection - management of immunisation and surveillance data and analysis in over 20 countries [15]
- Remote data collection (including immunisations) and real-time monitoring in Asia [15]
- Disease monitoring for mobilisation of vaccination teams in Nepal [16]

In South Africa the majority of current mHealth solutions are focussed on combatting HIV/AIDS through education and awareness, remote data collection, remote monitoring and diagnostics as well as treatment support [15]. No mHealth solution to date addresses the vaccination of children.

A large body of evidence has shown that mHealth services increase clinical attendance [17] and compliance [18]. Mobile health services can be applied in a similar manner to potentially increase vaccination coverage on lower levels of health care.

1.3 Research design

This section discusses the research basis of this study.

1.3.1 *Knowledge gap*

As far as could be established, no mHealth project in South Africa aims to improve vaccination coverage. The feasibility and business case of such a service for improved information management for preventative care in South Africa are unknown.

1.3.2 *Problem statement*

In South Africa, there are inequalities in vaccination coverage with low coverage in certain areas. Current routine vaccinations are not sufficient and an alternative solution is required. The potential of mHealth to strengthen the primary health care system through improved information management is acknowledged but not implemented in the current vaccination system.

1.3.3 *Research purpose*

The purpose of this study is to determine the feasibility of an MHSV in the South African context and to develop business models for such an MHSV.

1.3.4 *Research questions*

The research questions for this study are as follows:

- RQ1 – Is an MHSV feasible in South Africa?
    - RQ1.1 – Is an MHSV feasible in terms of human factors?
    - RQ1.2 – Is an MHSV technically feasible?
    - RQ1.3 – Is an MHSV feasible in terms of information management?
    - RQ1.4 – Is an MHSV feasible in terms of policies and ethics?
    - RQ1.5 – Is an MHSV economically feasible?
- RQ2 – How should a business model be structured for an MHSV in South Africa?
- RQ3 – What will the effect of the NHI be on an MHSV?
- RQ4 – Have these research objectives been met?
- RQ5 – Is the research well-founded?

1.3.5 *Research objectives*

The objectives of this study follow from the research questions:

- RO1: Feasibility – Determine the feasibility of an MHSV in South Africa.
  - RO1.1: Determine the feasibility regarding human factors
  - RO1.2: Determine the technical feasibility
  - RO1.3: Determine feasibility regarding information management
  - RO1.4: Determine the feasibility regarding policies and ethics
  - RO1.5: Determine the economic feasibility
- RO2: Business models – Develop business models for an MHSV in the South African context
- RO3: NHI –Determine the effect that the NHI will have on an MHSV
- RO4: Verification – Evaluate whether the research objectives were met
- RO5: Validation – Evaluate the validity of the research both internally and externally

1.3.6 *Rationale*

Both the UN and the WHO have recognized the potential of using mHealth to strengthen health systems and improve health care [19]. A large body of evidence has shown that mobile health services increase clinical attendance [17] and compliance [18]. There are some mHealth projects in South Africa, yet none address vaccination coverage. If the feasibility with relevant business models of an MHSV is known, such a solution can be developed and implemented.

1.4 Methodology

A feasibility framework and the development of business models are used to achieve the research objectives. The feasibility framework is populated through a literature study and a survey, while the business model development builds on the results from the feasibility framework. Table 1-4 shows which methods address which objectives.

Table 1-4: Research objectives covered by methods used

Method		RO1: Feasibility	RO2: Business models	RO3: NHI	RO4: Verification	RO5: Validation
Feasibility framework:	Literature study	X	–	X	X	X
	Surveys	X	–	–	X	X
	Case study	X	–	–	X	–
Business model development		X	X	X	X	–
Structured Interviews		X	X	X	X	X

The output of the feasibility framework is a feasibility dashboard and the output of the business model development is business models. Interviews with experts in the mHealth sector are used to

help verify and validate the research outputs. Further detail on the verification and validation of the research can be found in CHAPTER 9.

1.4.1 *Feasibility framework*

The selection of factor for the feasibility framework is discussed in APPENDIX A. The chosen feasibility framework combines five factors with the different levels of telemedicine service to form the framework for the feasibility study, as illustrated below:

Table 1-5: Feasibility framework for an MHSV

Feasibility	Micro-level	Meso-level	Macro-level
Human factors	Caretakers	Health care workers	Management
Technical	Mobile phones & software	Mobile network infrastructure	Health information system infrastructure
Information management	Information capturing	Information integration	Information system
Policies and ethics	Ethical aspects	Regulation of information and apps	National strategies
Economic	Costs & funding	National business case	Health financing

For further information refer to APPENDIX A.

Literature study

Literature from various sources is used in this study, including journals, grey literature, conferences on mHealth and telemedicine and, to a lesser extent, news reports.

Survey

A survey (APPENDIX E) was conducted in collaboration with André Hartmann [20] to investigate how mobile phones are used by staff in the Western Cape public health care sector. The purpose of the collaboration was to gain information that was lacking in available literature. The results from the survey are included in various chapters. For more detail on the survey results, refer to APPENDIX E.

1.4.2 *Business model development*

To define the business case for an MHSV, business models are developed. These business models should meet the following design requirements:

- DR1: Conform to business model criteria
- DR2: Show how value is created
- DR3: Have relevance to stakeholders
- DR4: Distinguish between the private and public health sector
- DR5: Predict the effect of the NHI

1.4.3 *Interviews*

Interviews were used to verify and validate the study's research and, to a lesser degree, review information on the feasibility, business models and the NHI. For more detail on the interviews, refer to APPENDIX G.

1.5 Outline of this Study

The following section describes the structure that this research follows, and what is covered in each chapter. Figure 1-1 shows the relation of the different components and chapters of this research.

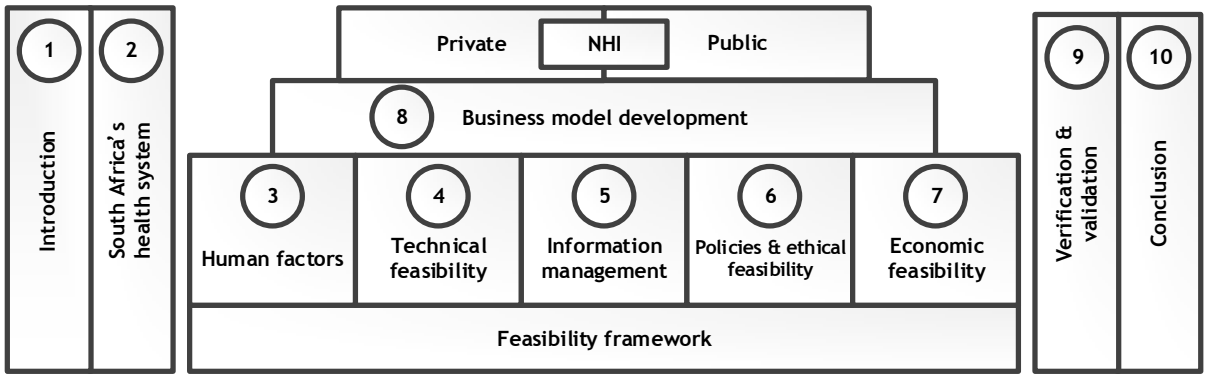


Figure 1-1: Research structure diagram

Introduction

This introduction chapter gives an overview of key aspects relevant to this study, followed by the research basis and methodology.

South Africa's health system

CHAPTER 2 sets the context for the feasibility framework by providing an overview of South Africa's health system in terms of history, structure and use of telemedicine and mHealth.

The human factor

0 to CHAPTER 7 investigate the feasibility of an MHSV in South Africa. CHAPTER 3 describes current human factors influencing the use of mobile health service among caretakers, health care workers and management in South Africa.

Technical feasibility

CHAPTER 4 investigates the technical feasibility of an MHSV in terms of mobile phones, mobile software, mobile networks and health information systems infrastructure.

Information management

CHAPTER 5 investigates the current use and capabilities of information management in South Africa. The primary health information regarding vaccinations captured in South Africa is investigated, followed by how information is managed in relevant health information systems. A case study is discussed to illustrate how the information management of an MHSV in South Africa can be handled.

Policies & ethical feasibility

CHAPTER 6 investigates policy and ethical regulations relevant to an MHSV in South Africa

Economic feasibility

CHAPTER 7 describes the financial factors that influence a mobile health service in South Africa. The key elements of the economic feasibility that are considered are cost and funding.

Business model

CHAPTER 8 proposes a business model for an MHSV in South Africa. The definition of a business model is first discussed, followed by a description of Osterwalder's canvas for business models [21]. Osterwalder's canvas is then applied in the proposition of a business model for an MHSV.

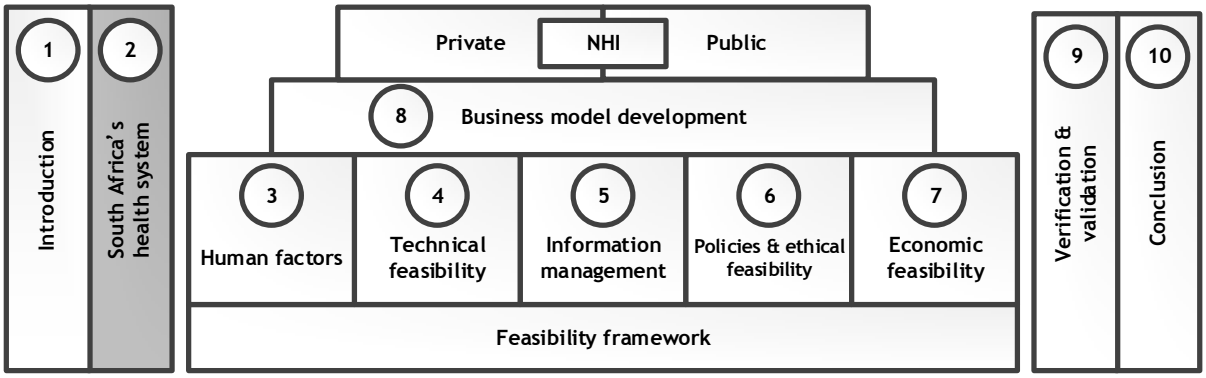
Verification & validation

CHAPTER 9 discusses the verification as well as the internal and external validation of the research presented in the previous chapters.

Conclusion

CHAPTER 10 synthesises all the work regarding the feasibility of and the business models for an MHSV in South Africa that was done as part of this study. Limitations of this study as well as possibilities for future research are discussed.

CHAPTER 2 SOUTH AFRICA'S HEALTH SYSTEM



The objective of this chapter is to set the context for the feasibility framework and business models by providing an overview of South Africa's health system in terms of history, structure and use of telemedicine and mHealth.

Health care systems can be broadly classified under the following types [22]:

- Free market: Health insurers contract private or not-for-profit health care providers
- National insurance: Health insurers provide standardised coverage for all citizens
- National health system: Government acts as a monopoly health insurer and provider

In South Africa there is both a free market and a national health system. The private health care sector is a free market in which health insurers contract private health care providers. There is also a national health system that provides free basic health care to all South Africans. There is currently no national insurance, but a National Health Insurance (NHI) is currently being conceptualised [23].

2.1 History

The health sector in South Africa is overseen by the government. Past governments have shaped the health sector to what it is today. For this reason the health sector experienced two distinct eras: the Apartheid era and the Democratic era.

2.1.1 *Apartheid era*

Interprovincial and rural-urban inequalities in health care have its roots in the Apartheid era of South Africa [10]. There is fragmentation within the public health sector and between the public and private sectors. During the Apartheid era, services for primary care were neglected while hospital care was favoured, receiving over 80% of resources. At the end of the Apartheid era, South Africa had 14 different health departments [10].

Private hospitals grew because of medical schemes funded by corporate capital and a governmental policy of privatisation. Resource disparities between public and private health care are attributed to a minority of the population contributing to the majority of health care expenditure. Public sources provide 43% of health care funding which is used to serve 86% of the population [11].

The nursing profession was established in the late 1800s and allowed only English-speaking, white ladies. Black nurses only received qualification in 1907. After World War II, many black nurses were trained due to nurse shortages, yet they still experienced discrimination and were paid less than white nurses [10].

2.1.2 *Democratic era*

After 1994 the public health system was transformed into a national service that provides free primary care. In total 1 345 new clinics were built, and 263 clinics were upgraded to increase access to health care. Progress was made in immunisation, drug availability, legislation and resource redistribution [10].

However, the uneven distribution of nurses continued after Apartheid, with many nursing colleges closing and nurses leaving the public sector. Doctors also moved from 40% in the private sector in the 1980s to 79% in 2007 [10]. Issues with human resource management include the employment of inexperienced managers and the tendency to retain incompetent senior staff and leaders, have plagued the public sector [10].

The Ministry of Health has provided good health policies, but there is a lack of allocated resources to implement these policies. The monitoring, implementation and assessment of these policies have not been emphasised and it has led to large differences in the quality of health care within the public sector [10].

One of the initiatives by the government to address the imbalance between public and private health and to provide better funding for public healthcare is the NHI, which has currently only been conceptualised but not yet implemented. The aims of the NHI are as follows [14]:

- Create fairness in sharing health care finances and resources
- Provide free health care when required
- Keep health care costs reasonable
- Achieve a healthier nation

2.2 Health facilities structure

South Africa has 3 880 public health care facilities [24]. They include different types of clinics, health centres and hospitals as shown in Table 2-1.

Table 2-1: Number of public health facilities in 2011 by facility type [24]

Facility classification	Number of facilities
Satellite Clinic	125
Clinic	3 074
Specialised Clinic	4
Maternal Obstetrics Unit (MOU)	1
Community Day Centre (CDC)	44
Community Health Centre (CHC)	238
District Hospital	253
Regional Hospital	55
Tertiary Hospital	10
National Central Hospital	6
Rehabilitation Hospital	3
Children's Hospital	1
Chronic Hospital	4
Orthopaedic Hospital	1
Psychiatric Hospital	23
TB Hospital	35
TB and Psychiatric Hospital	2
Private Hospital	1
Total	3 880

Primary health care is mainly accessed through clinics, with higher level hospitals only accessible through reference [25]. These hospitals are classified from a district level to a central level, with specialised hospitals performing non-standard functions. South Africa's public hospitals are classified as per Table 2-2.

Table 2-2: Number of hospitals according to facility classification [24]

Classification	Number
District	254
Regional	55
Tertiary	10
Central	6
Specialised	66

In the private sector, there are 216 private hospitals [26] compared to 394 public hospitals. However, when the amount of people using private health care is compared with those using public health care, it is evident that private health care has better access to health care facilities. In the general household survey [27], it was found that South Africans use public clinics (62%), private

doctors (24%) and public hospitals (9%). This finding shows that South Africans have greater access to public clinics than public hospitals.

2.3 Telemedicine and mHealth

The following section discusses what telemedicine and mHealth is, and its relevance to the South African context.

2.3.1 *Telemedicine and mHealth defined*

eHealth

The word "eHealth" is derived from a combination of the "e" in electronic and the word "health". Apparently the term was first used, with other "e-words", to convey the new opportunities that the Internet could bring to health care [28]. There are a variety of definitions for eHealth and no standard definition has been agreed upon. From a systematic review of published definitions [29], two universal themes of "health" and "technology" were identified. For this study, the definition from Vital Wave Consulting [15] will be used: "the use of information and communication technologies (ICT) for health services and information".

Telemedicine

The word "telemedicine" is derived from the combination of "tele", which means over a distance, and "medicine", even though "telemedicine" is not limited to medicine. In a systematic review on the definition of "telemedicine", it was found that "telemedicine" is a branch of eHealth that uses communication networks to deliver healthcare services and medical education over a geographical distance [30]. It was also found that the definition of telemedicine changed according to the context of the application.

mHealth

The word "mHealth" (also written as "m-health" or "mobile health") is the combination of the "m" in mobile and "health". The term was first defined in 2003 by Istepanian [31] as "the exploitation of the mobile telecommunication and multimedia technologies and their integration into new mobile health care delivery systems". mHealth forms part of eHealth, seeing that mobile phones are part of ICT. The definition for mHealth used in this study is also from Vital Wave Consulting [15]: the use of mobile communications for health services and information.

In the taxonomy of telemedicine [32] it is noted that mHealth has been classified as a separate domain of telemedicine based on the manner in which communication takes place. In the future the term may fade into becoming part of domains such as telemedicine, telehealth or e-health.

According to Gartner [33], the hype surrounding mHealth is becoming obsolete before plateauing. This is because mHealth is such a broad concept that emphasises the technology above the actual use. Another reason given is that mobile technologies are these days routinely incorporated into health care delivery.

2.3.2 *Reasons behind mHealth*

In 2002 the UN set the Millennium Development Goals (MDGs) which define various targets for nations to reach by 2015. Three of these goals are health related [34]:

- MDG 4: Reduce mortality of children under 5 years of age
  (target: two-thirds reduction from 1990 to 2015)
- MDG 5: Improve maternal health
  (target: three-quarters reduction of maternal mortality per 100 000 live births 1990 to 2015)
- MDG 6: Combat HIV, AIDS, malaria, and other diseases

From 1990 to 2009 South Africa has shown a reversal of progress on MDG 4, no progress on MDG 5 and insufficient progress on MDG 6 [35]. In 2009 child mortality was 69 per 1 000 live births, with maternal mortality being 400 - 625 per 100 000 live births [36].

The large scale uptake of mobile phones has created a platform that can be utilised to increase access to health care services and information. Mobile phones are able to reach further than any other technology or health infrastructure [15]. In South Africa over 99% of the population is covered by a mobile phone network [37], with 90% of households having a functional mobile phone in their dwellings [27].

Both the UN and the WHO have recognized the potential of using mHealth [19]. In a global survey on mHealth [19], 112 countries reported at least one mHealth initiative.

In a review of mobile phone use in preventive medicine and disease management [38], 23 articles were found on the use of mobile phones for disease management in telemedicine applications. The areas identified were:

- Disease management
- Disease monitoring
- Disease prevention
- Diagnosis
- Patient education

Because mHealth is a new development, concrete evidence showing the benefit of using it is still growing. Thus far, the following benefits have been proven [15]:

- Increased access to health care information
- Improved ability to diagnose and monitor sicknesses
- The delivery of health information that is appropriate and applicable
- Increased access to continual training for health workers

The benefits of using mHealth have been documented and show promise to improve healthcare in South Africa.

2.3.3 *mHealth in South Africa*

In the beginning of 2013, GSMA reported 63 mHealth services listed in South Africa [39]. The majority of these services address HIV/AIDS, seeing that in 2011 South Africa was the country with the highest number of people with HIV [40].

A global movement in maternal health care called MAMA (Mobile Alliance for Maternal Action) [41] is also being started in South Africa. MAMA aims to provide relevant maternal health information and support for mothers and expectant mothers via a mobi site, SMS, USSD, Mxit, and voice.

No mHealth services were found that directly address vaccination.

2.3.4 *Related projects*

In November 2010 the National Health Council (NHC) adopted the re-engineering of primary health care (PHC) [42]. This programme is based on teams of community agents working with health professionals. The three-stream approach is: ward based PHC outreach teams, school health services and district-based clinical specialist teams. The initial focus of these teams is the outcomes of the Negotiated Service Delivery Agreement 2010-2014 (NSDA) [43]:

1. Increasing life expectancy
2. Decreasing maternal and child mortality
3. Combating HIV and AIDS and decreasing the burden of disease from tuberculosis
4. Strengthening health system effectiveness

A project by Mobenzi [44] enables community health workers (CHWs) to use mobile phones to collect data on each patient visit. The system also includes automatic scheduling of visits to patients, including antenatal and postnatal visits. Three clinics are currently involved in the project.

For an MHSV, information from clinics can be integrated into a project like Mobenzi's to enable outreach teams not only to know of postnatal visits but also to know which vaccinations are required or outstanding.

2.3.5 *Barriers for mHealth*

In a report on mHealth solutions in low- and middle-income countries (LMIC) [45], the following gaps for mHealth were identified:

- The sizes of many studies on treatment compliance are not statistically significant.
- Most studies on treatment compliance are from high-income countries.
- Infrastructure in LMICs is not universal and reliable.

In a global survey on mHealth applications [19], the following aspects were found to be the top barriers to implementing mHealth solutions:

- Competing health system priorities
- Cost effectiveness
- Lack of knowledge of applications
- Policy challenges

A specific barrier to implementing mHealth solutions in South Africa lies in the strategy of integration of services [46].

Part of the integration of services strategy is to deliver an integrated maternal, child and women's health (MCWM) service. Currently, clinics are set up with different programmes (or service streams) with each programme having a specific function (e.g. TB, HIV/AIDS, vaccination, etc.). The integration of services will require health workers to perform all services from different programmes.

Such an integration of services can form a barrier for an MHSV if the system only functions for vaccination services. The integration of services also provides an opportunity to expand mHealth solutions to provide information management to all services. Currently different programmes are using different records, which can create confusion if each function has to be recorded in a different record for integrated services.

2.4 Mobile health solution for vaccination concept

The details of how an MHSV will work can only be defined through proper development. Only the basic concept is given here. A more detailed example is given in the case study of Pikinini (Section 5.4).

For an MHSV, the main users are caretakers, health workers and management. Caretakers can view the vaccination records of their children (probably through USSD), showing which vaccinations have been done and which are outstanding. Caretakers will also receive SMS notifications for when vaccinations are due and to remind them to visit a nearby clinic.

Health workers will be the main user to input information into the system, registering caretakers on the system and logging when a child is vaccinated (via USSD or internet). Managers (and administration staff) will be able to view reports generated by the system regarding the vaccinations done by nurses. These reports can be used for performance monitoring and identifying problem areas regarding vaccination coverage.

Initially such an mHealth solution will target low-performing areas through pilot programmes. The aim of the solution is to replace existing paper-based reporting systems regarding vaccination. Ultimately the solution can be expanded to include all data entry for nurse-patient contact. The greatest advantage of such a solution lies in improved information management for nurses and management.

2.5 Comparison of vaccination systems

The following section gives a brief comparison between a paper based vaccination system, a computer based system, and a mobile phone based system. Table 2-3 summarises the differences.

The current vaccination system is a paper based system, with a high turnaround time (time from data input to reports) and many interfaces (translation of data). The more interfaces exist, the higher the likelihood of data loss. Tallying data (in paper based systems) causes loss of data resolution.

A computer based vaccination system will have the advantage of a low turnaround time, and high report resolution. The cost for acquiring computers and necessary infrastructure for each health facility will be costly. Having a fixed position for a computer also reduces accessibility to the data entry point.

A mobile based vaccination system will have a lower cost than a computer based system in terms of infrastructure. High report resolution and low turnaround time is similar to that of a computer based system.

Table 2-3: Comparison of infrastructure for different vaccination systems

System	Accessibility	Cost	Interfaces	Report resolution	Turnaround time
Paper (current)	High	Low	High	Low	High
Computer	Medium	High	Low	High	Low
Mobile phone	High	Low to Medium	Low	High	Low

From Table 2-3 it can be seen that a mobile phone based vaccination system is advantageous over a paper and computer based system. More information regarding the current health care infrastructure can be seen in CHAPTER 4. Details regarding information management can be found in CHAPTER 5.

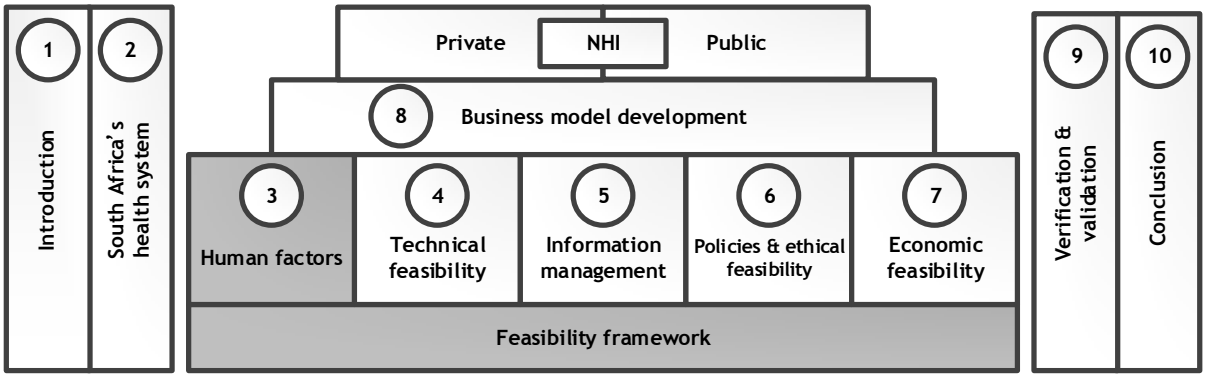
2.6 Conclusion

In this chapter, an overview of South Africa's health system was given. It was found that even though South Africa's health sector is facing challenges, progress has been made to provide health care to all South Africans. The NHI will provide more funding and resources for the public sector. An investigation of the possibilities of mHealth found that it shows promise to further improve health service delivery.

With the context of South Africa's health system set, the feasibility framework is applied in CHAPTER 3 to CHAPTER 7 with a summary of the entire framework given in Section 7.6.

SECTION 1 FEASIBILITY FRAMEWORK

CHAPTER 3 HUMAN FACTORS



In this chapter the current human factors influencing the use of mobile health service in South Africa among caretakers, health care workers and management is discussed.

The objective of this chapter (RO1.1) is to determine the feasibility of a mobile health solution for vaccination (MHSV) with reference to human factors.

Various stakeholders are involved in mHealth solutions. Friderichs [11] classifies the different stakeholders according to the following categories:

- Mobile operators
- Developers
- Integrators of telemedicine, eHealth, etc.
- ICT capacity builders
- Health community
- Policy and regulation

These stakeholders create the environment in which mHealth solutions, such as an MHSV, can operate. The end users of MHSV are caretakers and health care staff (including managers). The success of MHSV depends on both the stake holders and the end users. Even if stakeholders produce an MHSV, it still has to be accepted by end users.

To determine the feasibility with reference to human factors, the acceptance of mobile technology by caretakers, healthcare workers and management has to be investigated.

3.1 Caretakers

In order to determine caretakers' acceptance of mobile technology, studies from South Africa regarding mobile phones will be discussed.

3.1.1 *Mobile phone usage*

In the South African census of 2011 [27], it was found that 89% of South African households owned at least one mobile phone. This significant uptake of mobile phones in South Africa has created a platform for mobile health service delivery to households.

A study published by Research ICT Africa (RIA) in 2013 [47] investigated how South Africans use mobile phones. Results from surveys were divided into the base of the pyramid (BoP) and the rest of the pyramid (RoP). The economic term "base of pyramid" refers to the largest but poorest socio-economic group [48]. Some of the results are shown in Figure 3-1.

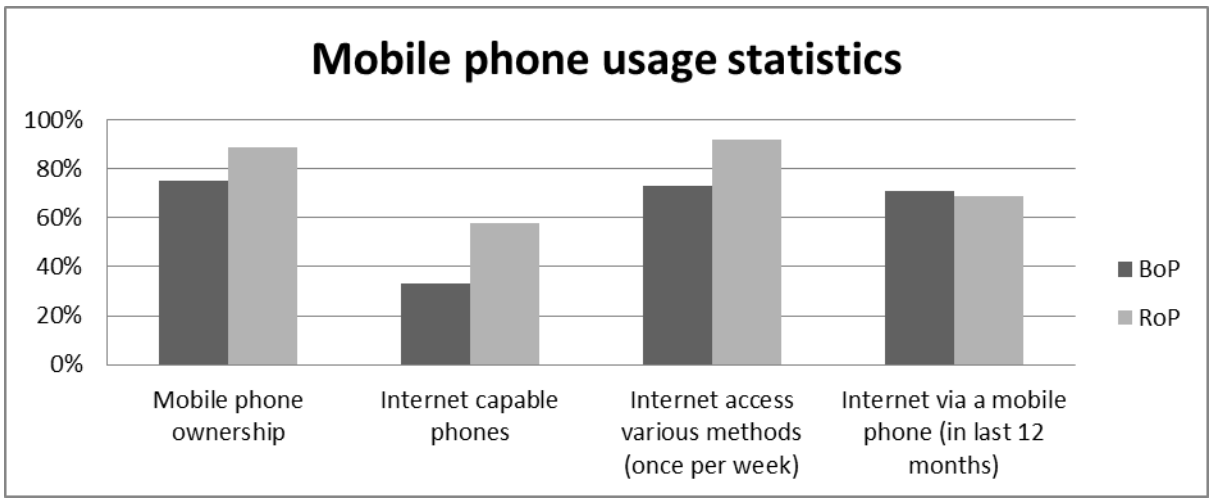


Figure 3-1: Graph showing various mobile phone statistics [47]

Personal mobile phone ownership was found to be 75% for the BoP and 89% for the RoP. Mobile phone penetration is high for BoP users, who are also those that have the greatest need for improved health service access. RIA's study [47] shows that users with mobile phones make calls (99%) and send text messages (97%). It indicates that users are familiar with using text and voice services for communication.

Even though mobile phone penetration is high, phones capable of Internet browsing was found to be 33.2% (BoP) and 57.7% (RoP). A large portion of users' phones are feature phones, not smart phones (See Section 4.1 for definitions). With the advance of technology, feature phones are growing in technological capability while remaining low in cost. In the not-so-distant future all feature phones will be capable of Internet browsing.

Regardless of personal phone capability, users that access the Internet through various means at least once per week were found to be 72.9% (BoP) and 91.9% (RoP). A large group of users use the Internet on a weekly basis, revealing that the Internet is a viable channel to use for mobile health services. Also, users who had accessed the Internet through a mobile phone in the last 12 months

were found to be 71% (BoP) and 69% (RoP). Most users therefore know how to access the Internet via a mobile phone, even if it is not with their own phone.

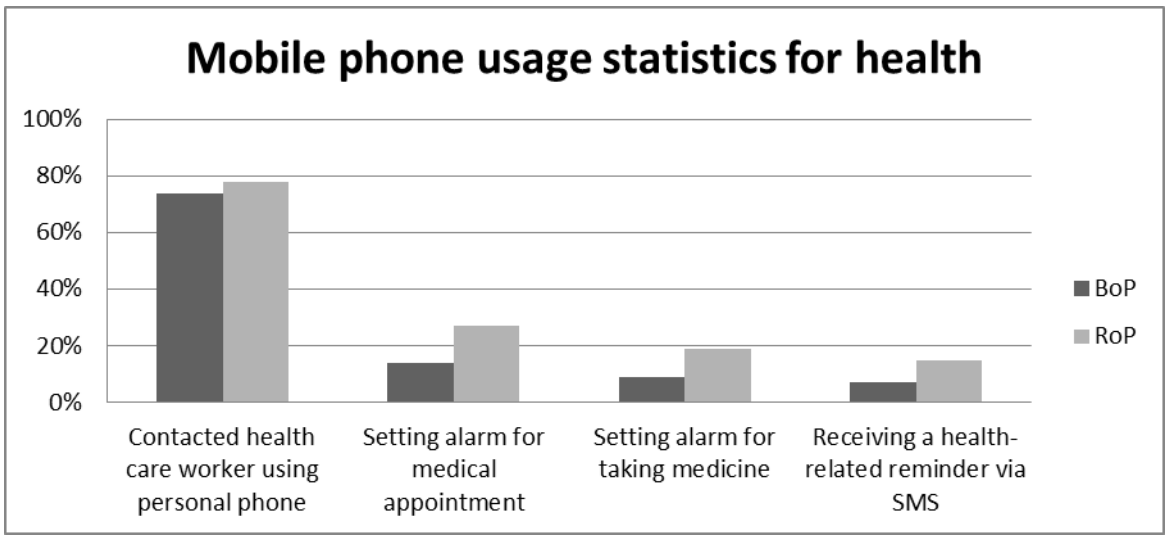


Figure 3-2: Graph showing mobile phone usage statistics regarding health [47]

The study by RIA [47] also examined the current use of mobile phones for health services. It was found that 74% (BoP) and 78% (RoP) of users have contacted a health care worker using their personal phone. Mobile phone owners are thus already communicating with health care workers via their mobile phones.

Other health-related findings regarding the use of mobile phone were:

- Setting an alarm for medical appointment: 14% (BoP), 27% (RoP)
- Setting an alarm for taking medicine: 9% (BoP), 19% (RoP)
- Receiving a health-related reminder via text message: 7% (BoP), 15% (RoP)

Using mobile phones for health services is already taking place in South Africa, even though the uptake is small. Most South Africans own a mobile phone and are familiar with accessing the Internet via a mobile phone. Most of them also access the Internet on a weekly basis. Many South Africans have contacted a health care worker using their mobile phone, with more advanced mobile services already showing a small uptake.

3.1.2 *Factors influencing mobile usage*

Even though most South Africans own a mobile phone, factors influencing mobile phone ownership and usage should be considered. A study done by Samuel *et al*. [49] showed that the uses of mobile phones differ according to users' gender, age, education and income.

In the study, 57% of respondents owning mobile phones were female and 60% of respondents who use mobile phones but do not have their own phones were also female. Slightly more females than males thus own and use mobile phones.

Mobile phone usage was highest among respondents ages 25 and under, with ownership highest among age 26-45. The increase in ownership with age may be due to higher economic activity within this age group. The older population may not be familiar with using mobile phones, calling for an MHSV to be easy to use. The ease of using an MHSV should be high in order to reduce the learning curve required to use the service. This will enable a greater age group to use an MHSV. Social factors such as grandparents raising children, population movement and AIDS orphans (APPENDIX G.2) should be considered and may pose a problem for an MHSV.

Mobile phone ownership and usage increases with increased education levels per population demographics. Most mobile phone owners and users have a secondary education level, which matches the population demographics. If mobile health services are to be accessible to the majority of South Africans, the content should be appropriate to a secondary or primary level of education.

Mobile phone ownership and usage was highest among the low income group (less than R500 pm). Income level therefore does not significantly challenge the use of mobile phones. Mobile health services can easily be delivered to the low income group in South Africa.

In can be concluded that, in order to reach most South Africans, the content of mobile health services should be adjusted to suit the profile of mobile phone users in terms of gender, age, education and income.

3.1.3 *Attitude towards mobile technology*

Mobile phone banking is a current mobile service that can be compared to mobile health services. Mobile commerce has received increasing attention from 2000 [50]. Similar to mobile health services, mobile commerce consists of a mobile service (commerce) given over a mobile network via a mobile device.

In a study investigating the predictors for the adoption of mobile phone banking in South Africa [51], it was found that perceived relative advantage, trialability (experimentation with innovation before use) and diversity of user needs influenced the first adoption. For a mobile health service, these factors should be taken into consideration during the development and deployment of a service.

With mobile phone banking, perceived sense of risk was also found to be a major limiting factor [51]. If sensitive data is shared via a mobile health service, the sense of risk should be addressed with appropriate technology and user information.

A study on a low-income mobile banking service [52] surveyed 215 users and 300 nonusers of the service. Users of the mobile banking service had a slightly better attitude towards technology than non-users with mobile phones. Non-users without mobile phones had a slightly worse attitude to technology than non-users with mobile phones. Positive views regarding the use of mobile phones for banking were considerably higher for users of mobile banking than for non-users (either with or without mobile phones) [52].

Using a service thus improves the view of the service for an end user. Even though the view of mobile health services may not be positive, trial use of a service before committing to it may turn a negative view to a positive view.

3.1.4 *Vaccination reminders*

Various studies have shown mixed results regarding the effectiveness of using mobile phones to improve treatment compliance [45]. Many studies are too small to be of statistical significance. There is evidence, however, that shows that SMS is the most effective way to utilise mobile phones for treatment compliance [53].

With unclear evidence on the effectiveness of using SMS reminders to improve treatment compliance, it is uncertain whether they will improve treatment compliance for vaccination in the South African context. It is also uncertain whether simple forgetfulness is the root cause of missed vaccinations. Social issues, such as raising children in different health districts and the health care of AIDS orphans, are factors that influence treatment compliance.

The scope of this study is not to investigate the motivation of caretakers or the root causes of their lack of compliance, yet such information would be critical for an MHSV. Future research will have to investigate the motivation behind caretakers taking their children to clinics for vaccination. Motivation and causes for lack of compliance may differ between different sections of the population.

3.2 Health care workers

The Health Systems Trust [24] reported that a high percentage of clinics (57%) have no administration support and no information management staff (79%) which increases the workload of nurses due to additional administration. In order to determine whether health care workers would be receptive towards mobile technology solutions, studies regarding health workers' acceptance toward telemedicine are discussed.

3.2.1 *Telemedicine acceptance*

A study by Cilliers and Flowerday [54] investigated the acceptance and use of telemedicine among health care staff in the Eastern Cape. The views of the respondents reflect a situation where telemedicine has been implemented, the necessary training was done and technical assistance is available. The study gives an indication of acceptance of technology by health care workers in South Africa. Overall the study [54] found that health care workers agree that telemedicine has increased the productivity, quality and efficiency of their work, with a positive behavioural intent to use telemedicine in the future.

When a telemedicine system has therefore been successfully implemented with the necessary training and assistance, health care workers are positive about using telemedicine in their daily work. For a mobile health system, implementation should be managed to ensure sufficient education and assistance for health care workers.

Rural health workers found telemedicine more useful than urban health workers [54]. A mobile health service should focus on areas where the benefit to health care workers is the highest, which can result in an increased use of the system.

Seventy-one percent of respondents found telemedicine easy to use, with 67% agreeing it was easy to learn to use [54]. Health workers thus have sufficient capability to learn how to use new systems, given that proper consideration was given to make the system user-friendly. Ease of use should be of importance for any mobile health service.

Even though some respondents considered themselves not knowledgeable in telemedicine, 53% agreed that it was easy to learn to use it [54]. Of the respondents that considered themselves knowledgeable in telemedicine, 86% indicated that they could use the technology. With increased knowledge of telemedicine, the ease of use seems to also increase. For mobile health services, health care workers need to be educated in the given system to ensure that they find it easy to use.

It was also found that respondents that are more knowledgeable about telemedicine agreed that their behaviour to use technology would be influenced by others [54]. The more workers are educated in a system, the more open they are to influence, which in turn can increase system use.

In summary it seems that health care workers will be accepting towards mobile health services. In order to ensure acceptance, implementation should include sufficient training, education and technical assistance. It will ensure that health care workers are knowledgeable of the service and therefore that there is high acceptance and use of the service. Mobile health services should also be implemented where the benefit is the greatest.

3.2.2 *Health information system use*

In a study by Cline and Luiz [55] doctors, nurses and hospital administrators were interviewed regarding the implementation of a health information system (HIS). All three groups initially agreed that it was easier to work with an HIS than with paper records. The groups also agreed that learning the new system was worth the benefit and that they would like to move to the HIS as soon as possible.

After the implementation of the HIS [55], respondents viewed the impact on patient experience as positive. The majority of hospital staff agreed on the benefit of electronic medical records (EMRs). Seventy-eight percent of nurses and 80% of administrators believed computer systems were faster than handwritten notes but only 55% of doctors agreed with this statement. The study proposed that this finding is because of the higher administration burden experienced by nurses and administrators.

Based on responses, the study found that the benefits of the system are only understood and appreciated if it is implemented with sufficient change management support. The study concluded that success in IT systems is as much a function of technology as it is of change management.

A study by Nicol *et al.* [56] found that clerks, data capturers and health information officers all have a higher confidence (61-79%) than competence (13-38%) in routine health information system tasks. Overall, personnel's competence in interpreting and using data was found to be deficient. It shows that personnel operating an MHSV should receive thorough training to ensure that they are competent in using the system.

3.2.3 *Mobile phone usage*

A study was done in collaboration with André Hartmann to investigate the mobile phone usage of health care workers. A questionnaire (APPENDIX E) was developed and distributed to health workers in the public sector to assess their mobile phone usage within the health sector. The 32 respondents included specialists (10), medical officers (8), medical students (8), community service doctors (3), managerial staff (2) and a medical intern (1).

From the responses (APPENDIX E) the following was found:

- 94% use their mobile device for health care purposes
- 91% access health information via the Internet
- 72% use their mobile device to capture, document or transmit medical data
- 75% use medical applications on their mobile phones
- 53% said financial benefit would motivate them to use mobile phones
- Only two respondents received any form of reimbursement for the use of their mobile device

Even though the survey size is not statistically significant, it indicates that the majority of health workers use their mobile phones for health care purposes. The survey also shows that it is not common for health workers to receive reimbursement for using their mobile phones for health care purposes.

No data specific to the mobile phone literacy of health care workers were found. It is known that South Africa has an aging nursing work force [36], which means lower mobile literacy [49]. It is further assumed that health care workers follow the mobile phone literacy of the general population as discussed in Section 3.1.1 and 3.1.2.

Poor working conditions have caused nurses in the public sector to move to the private sector or overseas where there are prospects of better payment for their skills [57]. With a low demand for nurses in the private sector, due to many tasks performed by private doctors, is thus assumed that higher skilled nurses are employed in the private sector.

In a pilot survey by Snyders and Van Dyk (APPENDIX I), responses from 13 health workers in the public sector showed that the acceptance of using mobile phones for healthcare is polarised. Health workers were either strongly negative about using mobile phones in healthcare or positive about the use and benefit thereof. The survey size is not statistically significant, but it does indicate that there are mixed opinions about using mobile phones in health care.

In an interview, Treurnicht (APPENDIX G.2) noted that the work environment of health care workers discourage them from using their mobile phone at work and that using a mobile phone in front of a patient may cause a variety of problems. This work environment should be carefully addressed in order to avoid creating confusion when training health care workers to use mobile phones.

3.3 Management

In an audit report [58] it was found that about a third of HIS staff rate their skill with pivot tables and graphs as poor or none and that two thirds rate their overall skill with DHIS as good or average. In a

study on routinely collected data quality [56], it was found that managers perceive their computer competence (68%) as higher than their actual skill (36%). In an interview (APPENDIX G.2) it was also reported that management have access to computers but that their skill in using computers is questionable.

In the same interview it was also stated that management is resistant to change regarding new information systems, including the use of mobile phones in healthcare. The pilot survey by Snyders and Van Dyk (APPENDIX I) found mixed responses from management regarding the use of mobile phones for health care. It shows that an MHSV should attain buy-in from management from the initial stages of development.

Where information systems have been implemented in the private sector, analysis skills and incorporation of information systems into management was reported to be found wanting [59]. It shows that management also requires training and restructuring to effectively use an additional information system.

3.4 Training

The Health Professions Council of South Africa (HPCSA) regulates health professionals in South Africa. The HPCSA implemented a continuing professional development (CPD) program [60] with which each health care professional is required to accumulate 30 continuing education units (CEU). Seeing that CPD is a legal requirement for health care professionals, various courses and material is made available for health care professionals. Funding is available for such courses and material to keep health care professionals up to date with current medical practices.

For an MHSV training programs for health care professionals can be used to improve the work culture regarding mobile phone usage. These training programs can obtain funding from health facilities, whilst providing CPD to health care professionals.

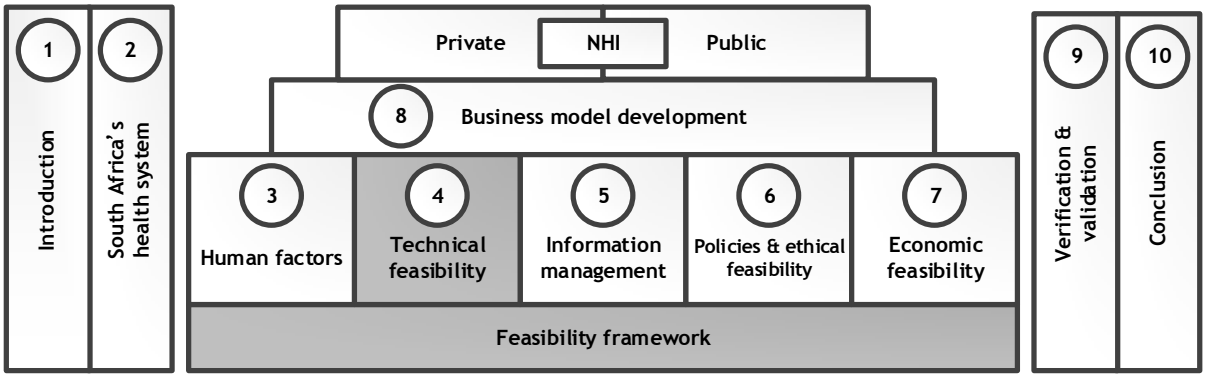
3.5 Conclusion

In this chapter the feasibility of an MHSV regarding human factors was investigated. It was determined that the mobile phone literacy of caretakers is affected by factors such as age and access to mobile phones. Social factors have to be taken into consideration when considering the end users.

The work environment of health care workers, which is set by management, is not conducive to mobile phone usage. Training together with change management will be needed to change the work culture of health care workers. The analysis skills of health care workers and management staff are

questionable. Management will require sufficient training to perform the needed analysis and incorporate the MHSV information system into their management structures.

CHAPTER 4 TECHNICAL FEASIBILITY



In this chapter the capabilities of technology in South Africa that is relevant to mobile health services are described. These technologies include mobile phones, mobile software, mobile networks and health information systems infrastructure. The objective of this chapter (RO1.2) is to determine the technical feasibility of a mobile health solution for vaccination (MHSV) in South Africa.

In Figure 4-1 an overview is given of the major modules involved in communication between a mobile phone, mobile network and server.

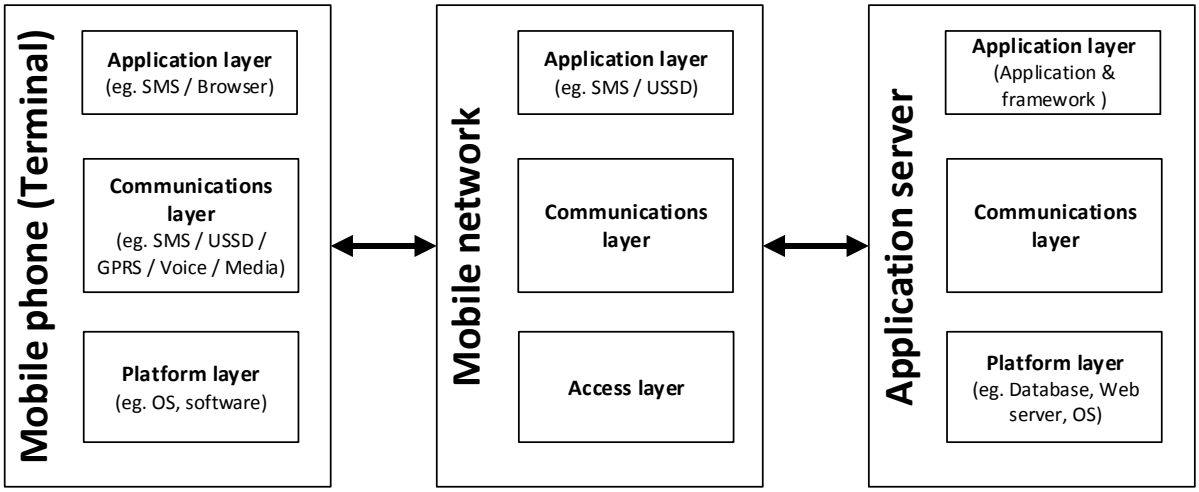


Figure 4-1: Overview of major modules of a mobile phone, mobile network and server [61]

Various ICT devices, including phones, laptops/PCs, tablets and other devices, are used for health purposes [61]. Different communication channels are also used to deliver a mobile health service. In a report on technology-enabled health programs [62], it was found that voice is the communication form used most often, followed by applications and SMSs.

4.1 Mobile phones

With advances in technology, mobile phones are no longer only used for voice communication but also for an array of other communication methods and technology. To distinguish between different types of phones, the terms “basic phone”, “feature phone” and “smart phone” are commonly used. The differences are as follows [63]:

- Basic phone: Capable of making and receiving voice calls, send and receive SMSs and use USSD services
- Feature phone: Often includes Internet access, camera and storage space
- Smart phone: Capable of adding additional applications, and have 3G and Wi-Fi capabilities

As technology advances and becomes less expensive, feature phones become more advanced by “inheriting” technologies from smart phones.

In 0, it was stated that 89% of South African households own a mobile phone [27]. In 2012 the market share majority for mobile phones in South Africa were Nokia (50%), Black Berry (18%) and Samsung (18%) [64]. In 2012 ten million smartphones were sold in South Africa of which 48% were Black Berry, 40% Nokia, 8% Android and 4% iPhone [64]. The percentage of smartphones in South Africa is projected to be 50% in 2015 [65]. However, in order to reach the wider population of South Africa, an MHSV needs to be developed for use on different mobile operating systems and different types of phones.

In 2010, 60% (9.5 million) of South African mobile phones could browse the Internet, but only 21% of these phones were used to do so [66]. By the end of 2011, the figure rose to 41% of phone users browsing the Internet on their phone [67]. The Internet user base in South Africa grew from 6.8 million in 2010 to 8.5 million in 2011 [68]. In 2011, 7.9 million users accessed the Internet via a phone, with 2.48 million accessing it exclusively via a phone [68]. By using the Internet to deliver an MHSV, more South Africans can be reached and development for different platforms does not have to be so extensive.

4.1.1 *Communication methods*

If end users have access to mobile phones, various methods of communication and applications are available. Applications for mobile health have been placed in the following six categories by Vital Wave Consulting [15]:

- Education and awareness
- Remote data collection
- Remote monitoring
- Communication and training for health workers
- Disease and epidemic outbreak tracking
- Diagnostics and treatment support

Different communication methods through mobile phones are listed and described in Table 4-1. The ways in which such methods are employed in mobile health services are also given.

Table 4-1: Mobile phone communication methods [61]

Method	Description
Native Voice	Voice transfer over a mobile network
IVR	Interactive voice response: Navigation through content via voice recognition and dual-tone multi-frequency (DTMF) keypad tones
SMS	Short messaging service: allows for the exchange of text messages
USSD	Unstructured supplementary service data: A communication protocol that can be used by most phones to communicate with a service provider's servers. USSD messages can be up to 182 characters in length and offer two-way communication between a mobile phone and a mobile server. The connection is established and remains open for the duration of the USSD service, offering a shorter response time than SMS. [69]
Text to audio	Phone or computer based translation of text into audio
Web	Hypertext documents accessed via the Internet
Apps	Software written to run on mobile phones (including instant messaging apps e.g. Mxit)
WAP	Wireless access protocol: Translates web pages into simpler format. Used in older phones and some Nokia phones. Used by Multimedia Messaging Services (MMS). Most new phones support full internet content and do not require WAP.
PCM	Please call me: A service where a user requests someone to call them back. This service is provided by all service providers in South Africa with a limited daily amount.

These different methods of communication can be used in an MHSV to communicate with end users. IVR and USSD are used in education and awareness, in remote data collection and in diagnostic and treatment support, while PCMs can be used to request communication from health workers [70]. Other methods can be used for any of the listed applications.

4.1.2 *Mobile network operators*

Partnerships with mobile network operators (MNOs) are vital to reach the majority of the South African population with an MHSV. There are six active MNOs in South Africa [71]. The market share of each MNO is given in Table 4-2:

Table 4-2: Market share of MNOs in South Africa [72]

MNO	Vodacom	MTN	Cell C & Red Bull Mobile	Virgin Mobile	8-ta
Customer %	43%	34%	10%	10%	3%

Red Bull Mobile is part-owned by Cell C and operates using Cell C's network.

4.2 Mobile software

Increased mobile phone ownership among the public and health workers [73] created a market for applications to be developed for health care purposed use by both the public and health care professionals.

4.2.1 *Mobile phone applications*

A large amount of health-related applications are available for popular mobile operating systems such as iOS, Android, Blackberry and Windows mobile. One concern about these applications is that there is little control over the health information that they provide because many applications are not developed under the supervision of health experts [74] [75].

A greater concern is that patients are vulnerable to possibly harmful health information due to their lack of formal health training and their tendency towards angst regarding their wellbeing [75]. In order to address this concern, the Food and Drug Administration (FDA) and the UK Medications and Health Care Products Regulatory Agency have started to regulate medical applications by means of selective approval of health care applications [75]. This measure does not prevent applications from being released to the public, but it is a start to assess health care applications.

A popular website called iMedicalApps [76] lists health care applications that have been reviewed by physicians and medical students. Although the content of the website is controlled by medical professionals, most of their applications are not regulated or reviewed by medical bodies, nor do they ensure the validity of the content, legally leaving the responsibility with the end user.

In 2012 a systematic review of health care applications for smartphones [73] identified 57 health care applications discussed in 55 articles. Areas addressed by these applications include disease diagnosis, drug reference, medical calculators, literature search, clinical communication, health information system applications for clients, medical training and general health applications. Health care professionals or students reported that disease diagnosis, drug reference and medical calculator applications were most useful.

4.2.2 *Text messaging for adherence*

A review by Car *et al.* [77] showed that mobile phone messaging reminders increases the attendance of health care appointments if compared to no reminders being send. It also found that SMS reminders have a similar effect to telephonic reminders.

4.3 Mobile phone networks

4.3.1 *Communication capabilities*

In South Africa the frequency bands allocated to mobile phone usage is as follows [78]:

- 900 - 960 MHz
- 1.7 - 1.8 GHz
- 1.9 - 2.1 GHz
- 2.5 - 2.7 GHz

Within these frequencies, MNOs use different communication protocols for communication with mobile phones. Various data communication protocols are used:

- 2G: GSM/GPRS/EGDE
- 3G: WCDMA/HSDPA/HSPA+
- 4G: LTE

Different MNOs in South Africa use different communication protocols, as listed in Table 4-3 per use in May 2013.

Table 4-3: Communication protocols used by MNOs [79] [80] [81] [82]

MNO	Protocols
8ta	2G & 3G, LTE (test)
Cell C	3G, HSPA+ (900/2100 MHz), LTE
Virgin Mobile	EDGE, 3G, HSPA+
MTN	GPRS, 3G, HSDPA, LTE (test)
Vodacom	GPRS, EDGE, 3G, LTE

The transfer rates for internet service providers (ISPs) are reported by Net Index [83]. The highest recorded transfer rates for mobile internet service providers are listed in Table 4-4.

Table 4-4: Transfer rates for leading MNOs

Mobile ISP	Transfer rate & protocol
Vodacom	14.42 & 6.55 Mbps (LTE), 4.02 Mbps (HSDPA)
Cell C	3.82 Mbps (HSPA+)
MTN	3.71 Mbps (HSDPA)

From the above, it can be seen that, depending on which protocol is used, a high data transfer rate is available for an MHSV. 3G is capable of 2 Mbps transfer rates [82]. The protocol used is dependent

on the physical infrastructure deployed by the MNOs. The following section discusses the coverage of these different types of protocols in South Africa.

4.3.2 *Mobile network coverage*

Most of South Africa's population is covered by MNOs' voice services, with only remote low population density areas left uncovered. MTN covered up to 98.6% of South Africa's population with GPRS in 2012 [84]. 3G coverage for Cell C was 72% [85], and for MTN 65% in 2012 [84]. Coverage from other MNOs could not be confirmed. These statistics show that almost all South Africans have access to voice services and data services. Even though the speed of data services differs, a basic service EDGE (400 kbps) is mostly available.

4.4 Health information system infrastructure

An MHSV involves the use of MNOs' infrastructure as well as health information system (HIS) infrastructure. In this section, the current state of HIS infrastructure is reviewed.

4.4.1 *Computers & networks*

Information regarding computers at primary care level is scarce and reference is only made to a few local cases. One such study on the e-health readiness of the North West province reported that the ratio of computers to doctors was 1:3 in rural areas and 1:2 in urban areas. It was found that most of these computers were not in the doctors' consulting rooms and that nurses and assistants were not using the computers. These computers were mostly used by administration for patient demographic information and accounting purposes [86].

In 2006 an audit was done among the HIS staff at national level, in view of the district health information system (DHIS) that was implemented [58] (see Section 5.1). The audit found that 96% of HIS staff had access to a computer but only 50% of all HIS staff had internet access, ranging between 98% in the North West to 25% in the Free State. An assessment of South Africa's HIS was done in 2009 [87], reporting that computers were available at district, provincial and national offices, yet internet access was limited and maintenance support was inadequate.

Even though information on the computer infrastructure in the HIS is limited, it can be inferred that the HIS has limited computers at health care facilities and that Internet connection is not the norm.

In the private sector, electronic claims are routinely sent to insurance companies [26] which means that information system infrastructure in the private sector is functional.

4.4.2 *National communication infrastructure*

The DHIS is used to monitor health indicators of all public health facilities in South Africa, and it is now used in all nine provinces [88]. See Section 5.1 for further detail on the DHIS.

The undersea cable capacity in 2011 was reported as 2.69 terabits per second (Tb/s) and was expected to rise to 11.9 Tb/s in 2012 and then double in 2013 [89]. Table 4-5 shows the undersea cables as of November 2012.

Table 4-5: Undersea cable capacity and completion dates for South Africa [90]

	Seacom	TEAMs	EASSy	MainOne	GLO1	WACS	ACE	SAex	BRICS	WASACE
Capacity (Tb/s)	1.28	1.28	4.72	1.92	2.5	5.12	5.12	12.8	12.8	40.0
Completion	Jul-2009	Sep-2009	Jul-2010	Q2 2010	Q3 2010	Q3 2011	Q2 2012	Q2 2013	2014	2014

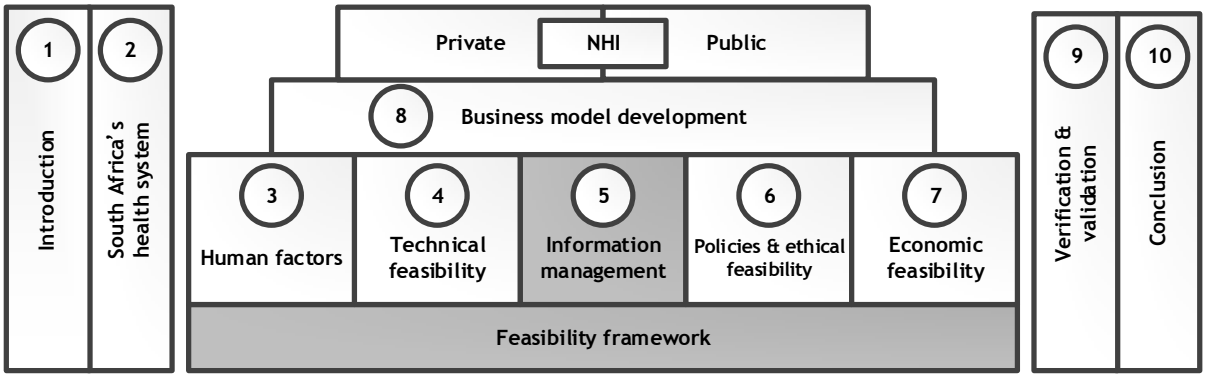
From Table 4-5 it can be seen that the capacity is expected to increase considerably in 2014. As Internet traffic and data usage in South Africa increases, the need for higher capacity communications increases.

4.5 Conclusion

In this chapter the technical feasibility of an MHSV was investigated. It was determined that South Africa has sufficient mobile phone networks to support an MHSV. The mobile phones used in South Africa have basic voice and text services, with some having Internet functionality.

The lack of infrastructure in the public health information system and the possible lack of mobile phones for health care workers are the only technical concerns for an MHSV. The private sector has better health information system infrastructure, but the lack of mobile phones for health care workers is still a possible concern

CHAPTER 5 INFORMATION MANAGEMENT



In this chapter the current use and capabilities of information management in South Africa is described. The objective of this chapter (RO1.3) is to determine the information management feasibility of an MHV in South Africa. What type of primary health information is captured in South Africa regarding vaccinations is investigated followed by how information is managed in relevant health information systems. A case study is given to show how information management of an MHSV in South Africa is handled. Mobile electronic health records

There are many theoretical benefits of electronic health records (EHR) [91], including the following:

- Increased efficiency
- Better quality data and information
- No loss of record
- Reduced processing time, duplication removal and reduced personnel costs
- Integrated patient care with fewer delays
- Better monitoring and managing

In additions to these benefits, there is also evidence that EHR systems can positively impact health facilities in the following manner [92]:

1. Improved patient outcomes
2. Decreased clinical visits
3. Financial benefit for health facilities
4. Improved efficiency

High income countries have the highest uptake of mobile EHR systems [19]. Most EHR systems are not exclusively designed for mobile phones but also for use with personal computers. A study by Prgomet *et al.* [93] found that mobile technology has a positive effect on response time, error

prevention, data management and data accessibility. Using mobile technology as an EHR input device can decrease input errors if it is well designed and implemented [92].

Regarding the application for vaccinations, the use of telephone and SMS reminders was found to improve appointment attendance [53]. Even though a mobile EHR system can benefit caretakers, health care workers and management, it has to be integrated into the existing information systems.

5.1 Information systems

The legacy of Apartheid has also affected the health information system in South Africa. With 14 departments of health at the end of Apartheid, the health information system was fragmented with no common standard [94]. In 1998 a District Health Information System (DHIS) was implemented for the public sector in the Western Cape [94]. In the private sector, the Council of Medical Schemes (CMS) was tasked to collect and publish information on private health care [26].

5.1.1 *District Health Information System*

The Health Information Systems Programme (HISP) is a research and development programme that started with the democratic era. Development of a standard national health information system (HIS) was nearly impossible because of the unique needs of the localised information systems. The HISP developed a dual focus of 1) developing standards for primary health care while 2) developing a district-based health information system [94]. The HISP has developed standard data sets for what data need to be captured nationally and provincially, with districts being encouraged to develop their own additional data sets. All provinces agreed on the national standard for health data by the end of 2001.

The District Health Information System (DHIS) was first implemented in 1998 in the Western Cape to analyse monthly data at district, regional and provincial level [94]. The DHIS has now been implemented in all provinces [88]. The DHIS software has gradually expanded into a management information system to cover hospital data, emergency medical services (EMS) data, environmental health system (EHS) data, client satisfaction surveys (CSS), core standards and measures of quality of care, survey data sets and data sets related to infrastructure and populations. It provides a large proportion of the information used for planning, budgeting, health service management, monitoring and evaluation at all levels of the South African health care system [95].

The first national minimum data set for primary health care was adopted in 1999 by the NHISSA Committee and rolled out to all public primary level facilities [95]. In 2001 a standardisation process was undergone to define which data elements should be reported nationally. The Expanded Programme on Immunisation (EPI) was reduced from 44 to 13 elements and EPI reporting was

included in the national standard reporting system. The national standard essential dataset consists of 46 data elements [94]. The monthly and quarterly reporting system to the national department of health (NDOH) has been standardized [4].

The DHIS now contains routine data representing around 1.4 billion patient encounters. The number of data items or values collected and captured as routine data records in the system increased from around 2.5 million in 2001 to 10.6 million in 2009 (i.e. over 400%). The number of DHIS users involved in capturing or processing this data increased from around 465 in 2001 to 1 180 in 2010 (i.e. around 250%). Most of this growth has been in the data capturing group. The number of highly skilled information officers and managers involved with data processing has remained modest [95].

5.1.2 *Private health information system*

Similar to the public sector, the private sector also has a dataset that has to be reported monthly. Within the private sector, the Medical Schemes Act tasked the Council of Medical Schemes (CMS) to collect and publish information on private health care. The CMS developed a minimum data set that all medical schemes have to collect [26].

The private sector sends large amounts of data to insurance companies electronically [26]. It includes routine electronic medical records that are processed for compensation. It shows that the private sector has electronic medical record systems in place and that information captured may be better than in the public sector.

The Private Health Information Standards Committee (PHISC) was established to coordinate health information standards for the private sector. The PHISC is mainly involved in implementing the International Classification of Diseases (ICD). As of yet, there has been no priority to develop a unified private health information system. Currently there is limited integration of information between private and public health care [26].

5.1.3 *Provincial health information systems*

Information management systems from grassroots level to district level are sparse, with about a third of provincial hospitals having computerised systems in place [88]. The hospitals that have information systems use software packages that differ from each other. Most of these packages are commercial software, with Meditech, Medicom and Clinicom systems used most.

The motive for using these systems is their cost-tracking functionality. Below is a table of commercial electronic medical record software per province [88]:

Table 5-1: Commercial electronic medical record software used in public hospitals in 2008 [88]

Province	System	Number
Eastern Cape	Delta9	10
Free State	Meditech	5
	Pads	12
Gauteng	Medicom	9
	PAAB	20
	Clinicom(pilot)	3
KwaZulu Natal	Meditech	4
	Medicom	1
Limpopo	Medicom	40
Mpumulanga	PAAB	8
North West	PAAB	20
Northern Cape	Nootroclin	12
Western Cape	Delta9	25
	Clinicom	15

Excluding commercial electronic medical record software, open source software like OpenMRS is used. Desktop productivity software such as Microsoft Access and Excel are used in many clinics. [88]. Excluding the EMR software, the Western Cape also uses a web-based information database called Sinjani.

Monthly reports from clinics are sent to hospitals, mostly via fax, but paper-based reporting and Excel reports also occur. Eighty-six percent of clinics have working telephone lines [13]. At hospital level, monthly reports from clinics and the hospital are mostly recorded into the DHIS. Most hospitals in the Western Cape and sub-district level use Sinjani or Excel templates to capture data for monthly reports. At district level Excel data in captured in Sinjani and at provincial level data from Sinjani is exported into the DHIS.

Even though these information systems in South Africa are dispersed and complex, the information captured and managed by the information system is of value.

5.2 Information integration

Considering the variety and dispersion of information management systems in South Africa, the integration of an MHSV into the existing information management systems will be a challenge. Points of integration into the existing health information systems have to be identified and interfaces have to be developed for information flow.

APPENDIX F provides an example of the complexity of data flow. The diagram is from a study done by Nicol [96] on the indicators used in monitoring prevention of mother-to-child transmission of HIV (PMTCT). It shows how information flows from facility level to provincial level.

At the end of this chapter (Section 5.4), a case study will be discussed to show a possible solution for the feasibility of an information management system for an MHSV that was developed in South Africa.

5.3 Information capturing

5.3.1 *DHIS*

The DHIS works through a tally system where reports from lower levels are tallied and mostly emailed to higher levels. The quality of such data is difficult to ensure due to the numerous interface levels from the initial recording to the final tally. Data resolution is also lost through tallying of data.

Mate *et al.* [2] investigated the quality of routine health data for PMTCT (prevention of mother to child HIV transmission) submitted to the DHIS in three districts of Kwazulu-Natal. It was found that 50% of data elements were incomplete and 87% were not accurate. This finding raises concerns about the quality of routinely collected data in the South African health system.

Challenges with the data quality in South African health information systems have also been reported. An investigation [97] found that the quality of data in the DHIS is poor at primary level, with nurses being unable to make use of the data. An assessment of the health information system of South Africa [87] found that surveillance reports are not timely or complete and that the data quality for measles vaccination coverage is inadequate.

Another survey done in 2009 on six key data elements in the DHIS [2] stated that elements were only reported 50% of the time and those entries were only accurate 13% of the time. Not all hospitals and clinics have computers, and data is thus entered into DHIS at sub-district level [87]. Web-based versions of DHIS are not yet available in provinces, resulting in data being exported from the various levels to ultimately produce a national report [4]. Translation of these reports creates the risk of reducing data quality.

5.3.2 *Primary records*

In a survey to gather information on the quality of care provided at primary health care clinics [13], it was found that records on patients were either not held at clinics or unavailable. Most clinics in the study took no interest in using patient data for performance monitoring. Different recording forms and methods as well as a lack of consistent quality were found within and between provinces.

In an evaluation of rural clinics in KwaZulu-Natal [97], it was found that data collection is perceived as a great work burden. Registers used for data collection at different clinics had different formats and their availability differed. Data collection reportedly took two days per month in 70% of clinics, with a minority of clinics having a clerk.

In a visit to the Khayelitsha (Site B) community health clinic on 19 October 2012, it was observed that nurses duplicate vaccination information onto the following:

- Road to health booklet – in possession of caretaker
- Child's medical record folder – clinical medical record
- Vaccination tally sheet – combined for report to sub-district
- Child vaccination register – detailed record of vaccinations given

Both the tally sheet and register were internally developed, seeing that there is no regulation or standard format. The road to health booklet [98] contains the vaccinations needed according to the national immunisation schedule [4].

5.4 Case study: Pikinini

The aim of this section is to present the Pikinini project as an example of an MHSV in the South African context. Detail is given on the information system of the project. The project has not been field tested, but its initial development shows what is possible in the South African context.

5.4.1 *Historical development*

The Pikinini project started as collaboration between Mezzanine and the Medical Research Council (MRC) of South Africa. Mezzanine Ware (Pty) Ltd is a company focusing on the deployment of mobile health solutions and the development of innovative business models. Solutions include workforce management, stock management, community care and mobile monitoring.

The Pikinini project was started by Jill Fortuin (MRC) due to the lack of accurate data concerning children's health in South Africa. Even though the project is aimed at caretakers of children, meta-data will be beneficial to health care management.

The aims of the project were as follows:

- Capturing data of new-borns
- Monitoring children's growth
- Tracking the vaccination schedule of children
- SMS reminders for caretakers
- Performance reports for management

At first the development focused on a native app for a Symbian-based Nokia phone, but development changed to a web-based platform that could be accessed via any web-enabled mobile phone. At the end of 2012 a working version of the web-based Pikinini was developed through a

collaboration of the MRC (Jill Fortuin), Mezzanine (Casper Strydom) and Stellenbosch University (Frans Snyders).

Nearing the end of 2012, the Telemedicine and mHealth unit at the MRC was closed and further development of the project was put on hold. The Burden of Disease Research Unit of the MRC took interest in the project before the closure of the Telemedicine and mHealth unit, yet no further development took place by July 2013. Currently a funder or client is sought for further development of the project.

5.4.2 *System configuration*

The Pikinini project was developed on the Mezzanine platform. Using a platform to develop solutions decreases the cost of future developments. This aspect is further discussed in the section on Cost of development (7.3.3). Figure 5-1 shows the configuration of Mezzanine's platform, called Mezzanine Helium.

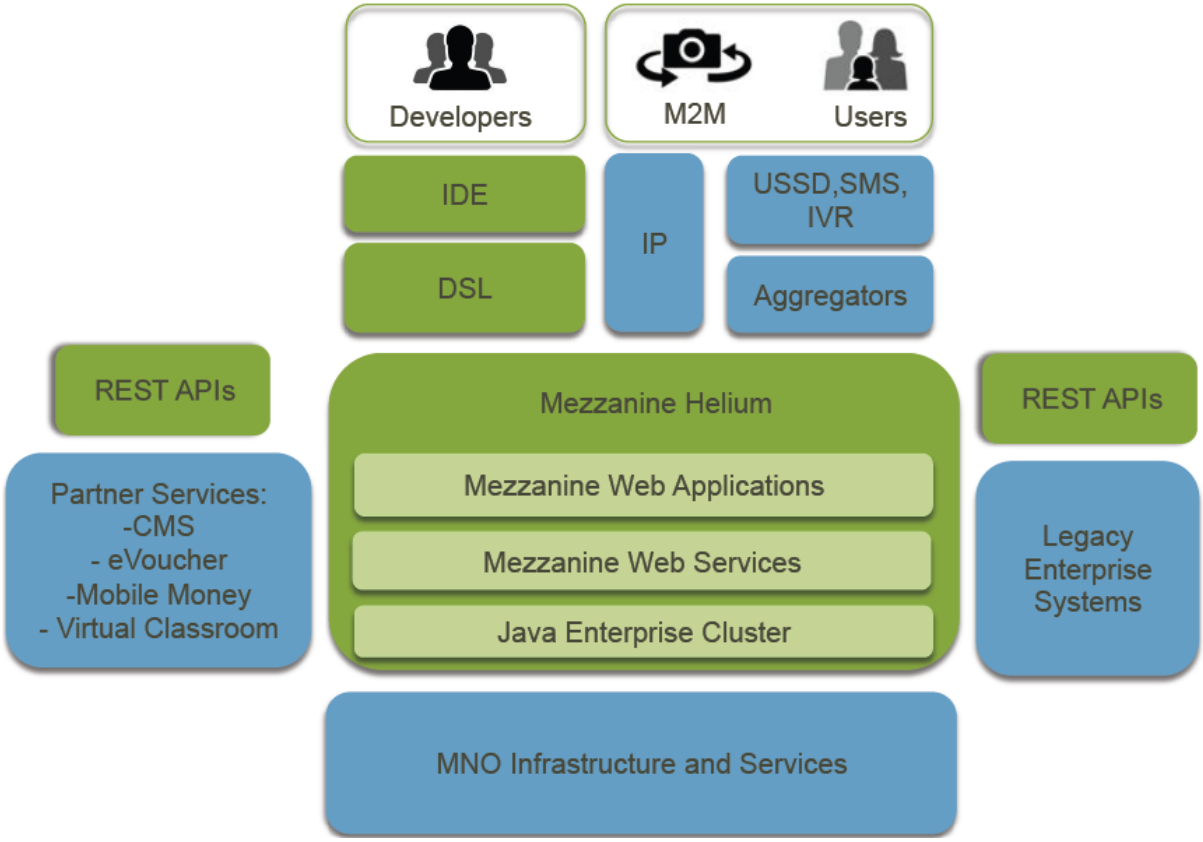


Figure 5-1: Mezzanine systems configuration [99]

The figure above shows the functionality and services that the Mezzanine platform offers. At the top are developers who use the integrated development environment (IDE) to develop solutions using the Mezzanine Helium platform. End users interact with the platform via the services of USSD, SMS and IVR (see 4.1.1).

The Mezzanine platform enables integration with MNO infrastructure and services as well as external services and systems via the application protocol interface (API). This capability makes for faster development of new solutions. Providing a single platform for multiple services allows for centralised information management. Financial and health information is stored via the platform, which results in the following security features [99]:

- SHA-512 encrypted passwords
- Multiple salt values / iterations
- Verified contact information to secure password recovery
- Brute-force resistance using retry delays
- Built-in deactivation for multiple failed login attempts
- Built-in two-factor authentication
- Role-based authorization
- OAuth authentication ensuring passwords are never entered into any third party applications
- Extensive audit trails of user activity

5.4.3 *Operation*

The Pikinini project was aimed at caretakers with children, but meta-data would also be beneficial for health care management. The users of the system included caretakers, nurses and management from facility level up to national level. Figure 5-2 gives an overview of the relationships between the users and other entities. (In the diagram and during the discussion thereof, “caretakers” are referred to as “parents”.)

Users that can access the Pikinini system are shaded grey. Many-to-one and one-to-one relationships are also shown between entities. What is not shown is that information from the immunisation schedule and parts are transferred to the immunisation record and items of the child.

Managers have access to information below them in order to monitor their section’s performance. Reports can be generated automatically and the need to pass on information to higher levels of management would be reduced. Greater data integrity can be ensured and more detailed reports can be generated than manual reporting.

Even though parents are the main users of the service, nurses are the main administrators. The nurse’s role is to register new parents and children and to complete forms regarding what immunisation was given. The aim of the system is to incorporate data elements that are being recorded to the extent that nurses do not have to record any data for children on external systems.

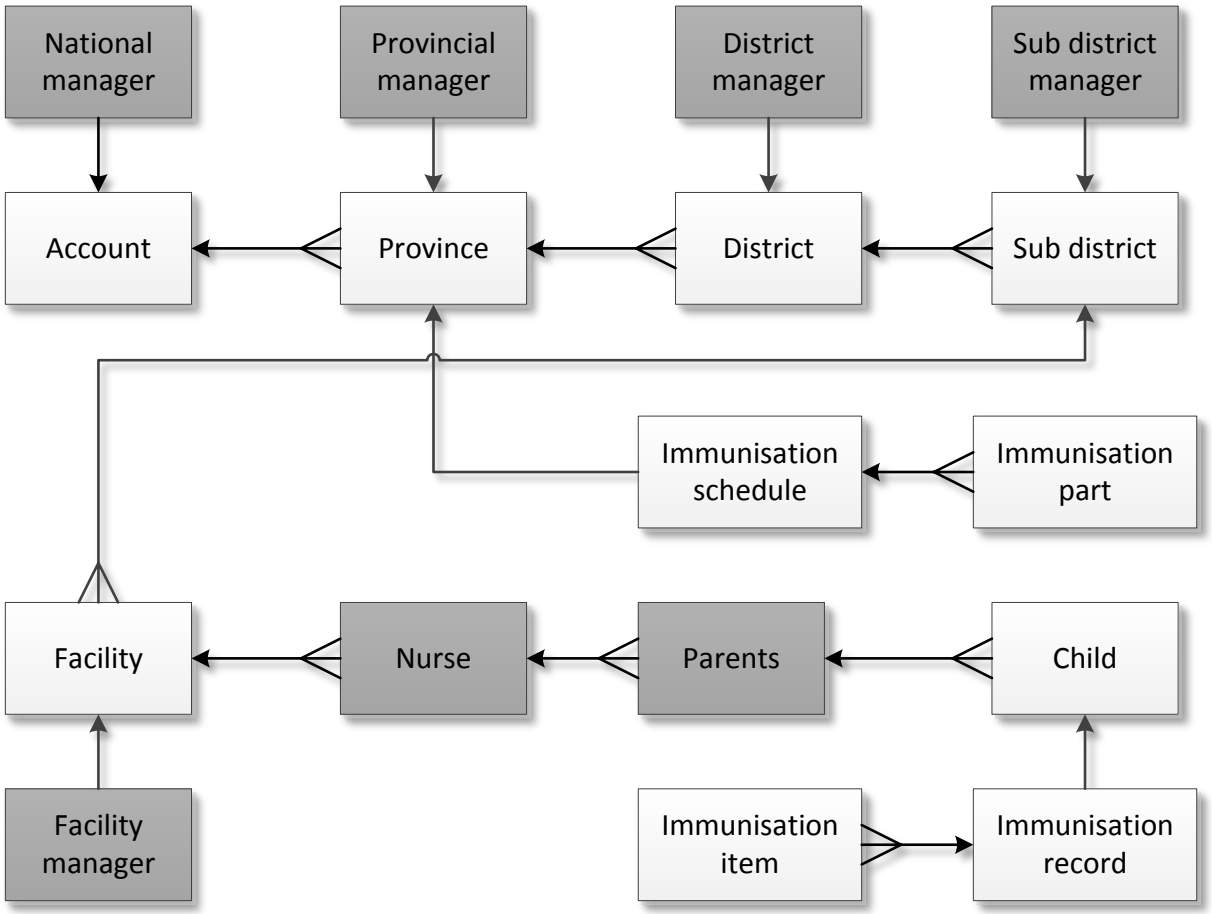


Figure 5-2: Relationship overview for Pikinini

Provincial managers have the added responsibility of adding additional vaccinations to the immunisation schedule as needed per province. The national manager is responsible for the initial creation of the account. All managers are responsible for registering managers (or nurses) below them onto the system, thus registering users via a cascade model.

The Mezzanine platform that Pikinini is built on is accessible via the Internet, making Pikinini accessible via any web browser on any personal computer or mobile phone that has an Internet connection.

5.4.4 *Data structure*

Following on the relationship overview diagram in Figure 5-2 is the entity relationship diagram (ERD) given in Figure 5-3. It shows the data elements that are captured for each entity and their relations.

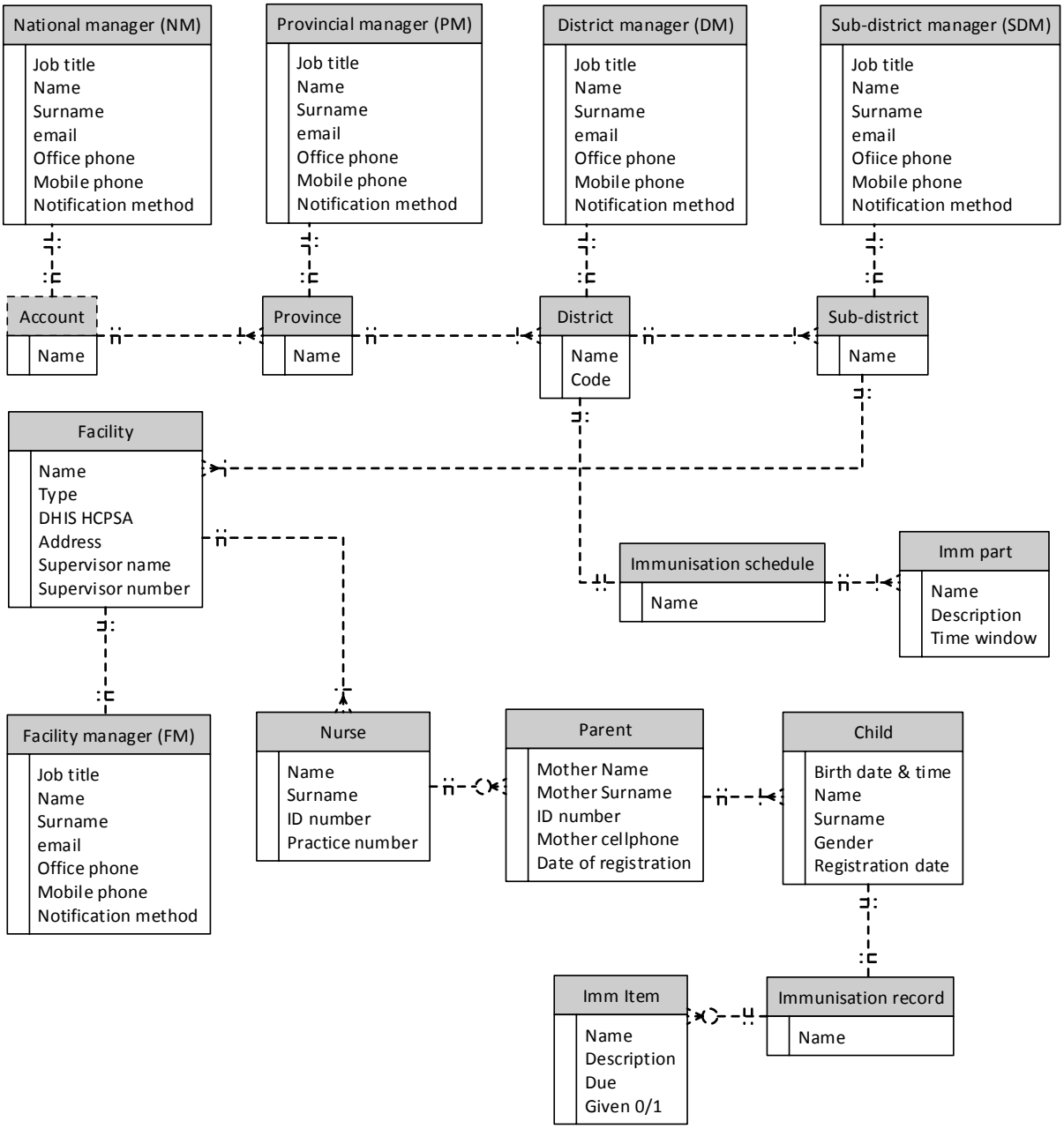


Figure 5-3: Entity relationship diagram for Pikinini

The ERD in Figure 5-3 shows the relationships between the different entities in greater detail. All information recorded by the system is stored on a centralised database server. Various queries can be sent to the server for inquiries or generating reports.

5.4.5 *Lessons learned*

During the process of the development of Pikinini, insight was gained into the mobile health solutions environment in South Africa. This section reflects on lessons learned during the development process.

Collaboration is vital

Mobile health solutions involve various role players, including MNOs, technology developers, health facilities and health organisations. The involvement of these different role players from start to finish in the design process of the mobile health solution is vital.

Funders are key

The current status of the project is that a client or funder is needed for further development. Development can take place with the help of university projects, but ultimately a client has to fund development and take ownership of the project.

Technology is a tool

The technology to develop almost any kind of mobile health solution is available. The limitations of mobile health solutions are not innovation and possibility but business cases and client funding for development.

Due process is required

The due process required for rolling out an MHSV is extensive and cannot be done simply in a year's time. The development of an MHSV is a long-term project requiring ethical approval, pilot studies and involvement of all relevant parties at each stage of development.

Integration is challenging

The health sector is resistant to change and the introduction of new technology. Adding additional systems to the current health system is seen as a burden, even if a new system has great potential. The key for integration is a hands-on, end-user-focused development and support process, with the support of all relevant authorities.

If a new information system is introduced, all existing systems need to be taken into consideration and all possible overlaps need to be identified and addressed. Ideally, pilot sites should be identified where the whole information system of the health facility can be integrated and transferred to a mobile platform.

Data capturing is a burden

Nurses are burdened with a myriad of forms that they have to complete, duplicating the same information many times over on different forms. Any additional forms or systems are seen as a burden. Creating a single location where data is captured, with forms containing the minimal amount of data elements, would reduce the burden of data capturing for nurses and free the limited number of nurses to do much-needed health related work.

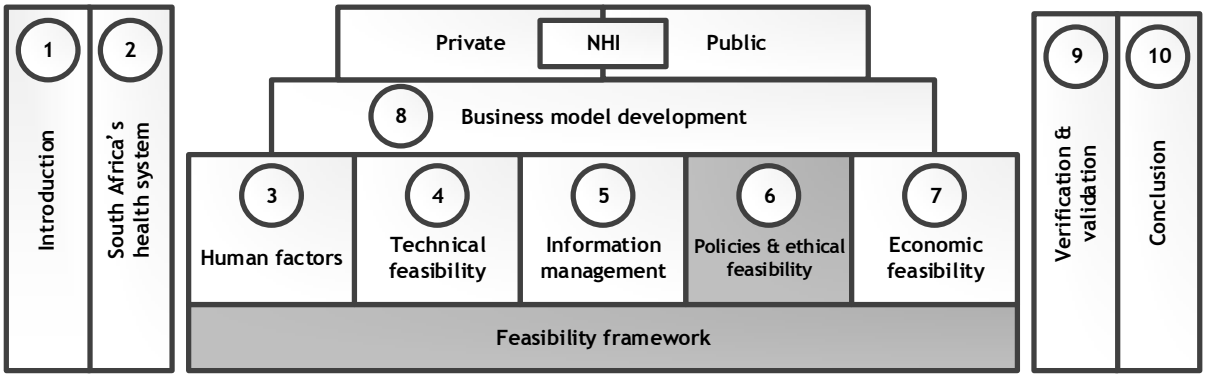
5.5 Conclusion

In this chapter the information management feasibility of a MHV was investigated. It was determined that the DHIS functions on a district level but that there are multiple systems (or none) on lower levels. Where there are information management systems, integration into the MHSV will have be managed. The quality of information captured is a challenge, and measures need to be taken to ensure completeness and accuracy of data entered into the MHSV.

Functional information management systems were found in the private sector. Integration into these systems can also be managed. Quality of data may be better due to routine electronic reporting for compensation. Information quality still has to be ensured for the MHSV, and it is thus labelled a challenge, as it is in the public sector.

A case study showed that the information system of an MHSV is feasible.

CHAPTER 6 POLICIES & ETHICAL FEASIBILITY



In this chapter the policy and ethical regulations relevant to a mobile health solution for vaccination (MHSV) in South Africa is described. The objectives of this chapter (RO1.4 and RO3) are to determine the feasibility regarding policy and ethics of an MHSV in South Africa and to determine the effect that the NHI will have on an MHSV.

In South Africa the department of health (DOH) is responsible for the development of policy regarding the use of mobile phones for health purposes. The DOH developed the eHealth strategy [43] which gives room for mHealth solutions in South Africa. In terms of ethics, the Health Professions Council of South Africa (HPCSA) released general ethical guidelines regarding eHealth services and is involved in regulating eHealth services.

6.1 Ethical aspects of telemedicine

With the increased use of ICT for health, the ethical guidelines for using it need to be developed without compromising well-established medical practice ethics [100]. A literature analysis conducted in 2006 [101] reported that, when implementing information technology, physicians experience barriers regarding standards for the exchange of medical data, privacy concerns and legal aspects.

6.1.1 *Overview of ethics in telemedicine*

There are various papers on the ethical aspects of telemedicine. Stanberry [102] lists 10 legal and ethical aspects relevant to telemedicine. Demiris *et al.* [103] gives a framework for the ethical consideration of the utilisation of telehealth technologies by nurses in homes. Mechael [104] lists different ethical aspects of telemedicine in Africa. Brown and Adams [100] discuss ethical considerations for ubiquitous healthcare using multiple ICT sensors. Mars and Jack [105] review regulators' ethical concerns for telemedicine and Stanberry [106] mentions ethical concerns for distance consulting and diagnosis.

From the above mentioned sources [100] [102] [103] [104] [105] [106], the following common ethical aspects have been identified as relevant to an MHSV:

- Informed consent
- Confidentiality and data security
- Surveillance and censorship
- Liability for practice

Caretakers have to give informed consent to use an MHSV, even if no consultation is done through the service. Informed consent will cover what will be done with caretakers' information and to what degree the caretaker's anonymity will be protected.

Confidentiality and data security determines how caretaker information will be kept private and how data storage will be secured. Surveillance of caretakers on a meta-scale will help management to deliver better healthcare, but censorship should be included to protect the privacy of caretakers.

Liability of practice refers to the health workers' ultimate responsibility for the treatment of the caretaker, regardless of the information or guidance provided by an MHSV.

6.1.2 *Ethical guidelines in South Africa*

A review of the ethical aspects of telemedicine found that only three countries and one association publishes ethical guidelines. There are general guidelines for health website code of conduct, doctor-patient relationships, consent and communication, security and confidentiality [107].

Jack and Mars [107] highlight the need for ethical and legal guidelines in South Africa, noting that guidelines for developing countries may differ from developed countries due to resource constraints.

Core principles for professional practice of telemedicine were developed by the Interdisciplinary Telehealth Standards Working Group (ITSWG) [108]. However, existing ethical guidelines and regulations for telemedicine are according to a one-size-fits-all approach that is insufficient in addressing the needed ethical concerns for telemedicine [105].

The state of legal frameworks and national policies regarding e-health is an indicator of the maturity of a country's development of e-health [107]. In South Africa, the national department of health published ethical guidelines for telemedicine in 1998, but these guidelines have little to do with health practice and more to do with commercial telemedicine suppliers [105].

In South Africa there are only general ethical guidelines for health care professionals that are determined by the HPCSA, leaving many grey areas for telemedicine services. In May 2011, the

HPCSA referred Sanlam and MTN's mobile help line and the 'Hello doctor' service to their undesirable business practice committee for consideration [109]. The HPCSA stated that physical examination and assessment was a 'general rule' for correct diagnosis, effectively ruling out any diagnosis done over a telephone. The South African Medical Association (SAMA) further affirmed the need for face-to-face evaluation to ensure ethical management.

The HPCSA's telemedicine guidelines have received other criticism as well, including being called deficient [105] and out-dated with a one sided approach [110]. In 2007 the telemedicine guidelines were circulated to various experts for comment and were found to have major omissions and provisions that would challenge telemedicine uptake. A final telemedicine guideline has not yet been finalised to date [12].

6.2 Policies

Internationally recognised standards are followed in the health informatics sector in South Africa. South Africa is part of the International Organisation for Standardization Technical Committee (ISO/TC 215) Health Informatics [88]. The national diagnosis coding standard is the International Statistical Classification of Diseases and Related Health Problems version 10 (ICD-10). The public messaging standard is Health Level 7 (HL7 v2.4).

The National Health Care Management Information System (NHC/MIS) defines the core modules that all levels of health care should have as follows [43]:

- Patient registration
- Basic summary care record
- Patient billing
- Appointment scheduling
- Clinical pharmacy
- Patient Master Index (PMI)

The implementation was given to provincial departments of health, which resulted in a variety of systems being implemented, as shown earlier in Table 5-1. Development of a national electronic health record system started in 2008 when a system named eHR.za won the tender by the State Information Technology Agency (SITA). No timeframes on implementation are given on their internet page to date [12].

6.2.1 *Information*

In South Africa, privacy and autonomy are constitutional rights [12]. According to the National Health Act, consent must be given by a patient before information may be released. The data-

protection law, in the form of the Protection of Personal Information Bill [111], has been passed by the National Council of Provinces and can soon become law. The principles of the law are as follows:

1. Accountability
2. Processing limitation
3. Purpose specification
4. Further-processing limitation
5. Information quality
6. Openness
7. Security safeguards
8. Data subject participation

Currently, mobile phone users fall under negative approval, which means they may receive text notifications regardless of whether they want to. Users can be sent text notifications until they opt-out of the service. Under the new information bill, only one text message may be sent to a mobile phone user, after which a positive response is required to continue the service. All MNOs in South Africa subscribe to a privacy policy that puts them under the obligation to protect user confidentiality of both information and communication [112].

The broader context of electronic communication and transactions is regulated by the Electronic Communications and Transaction Act (ECTA) [12]. Various other security protocols are also in place for keeping electronic communication secure (e.g. SSL and WPA) [113]. Examples of additional security in an information management system are shown in the Mezzanine platform as described in Section 5.4.2.

6.2.2 *Mobile phone and app regulation*

South Africa's medical devices and apps are unregulated with no legal requirements for safety and quality standards, as is also the case in developed countries like the United States and Europe [11]. Private health care demands international safety and quality standards while public tenders are price based. [11] International regulations on mobile health hardware and software are still unclear, with hearings currently examining how the Food and Drug Administration (FDA) will regulate mobile medical applications (MMAs) [114]

The FDA issued draft guidance for MMAs in July 2011. The FDA aims to regulate apps that are developed for medical purposes but not to regulate general health and wellness apps [115]. Most MMAs developed for medical purposes require the less stringent 501(k) approval process, compared to the more stringent Premarket Approval Process (PMA) [115].

In March 2013 the FDA [116] reported that respondents to the draft guidance favoured the narrow risk-based approach. The FDA confirmed that it is mostly concerned with mobile apps that meet the definition of "device", meaning apps that are used as an accessory to a regulated medical device, or apps that transform a mobile platform into a regulated medical device. It was also stated that the proposed mobile medical app policy would not apply to electronic health record or personal health record mobile apps.

6.2.3 *National strategies*

The two national strategies relevant to an MHSV, the eHealth strategy and the NHI, will be discussed in this section.

eHealth strategy

The eHealth strategy was released in 2012 by the DOH [43]. The mission of the strategy is "to establish eHealth as an integral part of transformation and improvement of health care services in South Africa". The DOH's document gives an overview of developments and challenges for eHealth in South Africa and lays out objectives and a "roadmap" with various strategic priorities. The strategy expands on how eHealth can be leveraged to achieve the four health outputs of the Negotiated Service Delivery Agreement 2010-2014 (NSDA) [43]:

5. Increasing life expectancy
6. Decreasing maternal and child mortality
7. Combating HIV and AIDS and decreasing the burden of disease from tuberculosis
8. Strengthening health system effectiveness

The NSDA ties in with the WHO's MDGs as given in Section 2.3.2. Although the eHealth strategy does not give sufficient guidelines for the implementation of eHealth solutions, it still provides government with a start to develop guidelines for eHealth.

National health insurance

The NHI is one of the DOH's strategies to address resource and service inequalities in the public health sector. Piloting of the NHI has already started in 10 districts by April 2012 [117] and a white paper on the NHI is expected in 2013 [23].

The goal of the NHI is to ensure that all South Africans have access to appropriate, efficient and quality health services [117]. The aims of the NHI [14] are to:

- Create fairness in health care finances and resources
- Provide free basic health care
- Keep health care costs reasonable
- Achieve a healthier nation

The objectives of the NHI [23] are to:

- Improve access to quality health care for all South Africans
- Pool risks and funding into a single NHI fund for equity and social solidarity
- Mobilise and control key financial resources to obtain services for all South Africans
- Strengthen the under-resourced public health care sector

The information system of the NHI will be designed to support the following [118]:

1. Monitoring the degree of coverage across all sectors
2. Tracking the health status of patients and produce disease profile data
3. All financial and management functions
4. Monitoring the utilisation of healthcare benefits
5. Quality assurance for healthcare providers
6. Generating reports for health facilities and health system management
7. Research and documentation to support changes in health care needs

Funding of the NHI will take place through mandatory membership for all South Africans. The mandatory contribution of individuals will vary according to income and age. Payment will be according to the ability of the individual and benefits according to the needs of the individual [119]. Additionally, employers will be required to match employees' contribution to the NHI fund [117].

According to the GSMA [11], the introduction of the NHI presents a significant opportunity for the mHealth industry. Value can be added through establishing public-private partnerships that can extend primary healthcare services via mobile technology. This opportunity can only be realised if the mHealth solution is aligned with the NSDA.

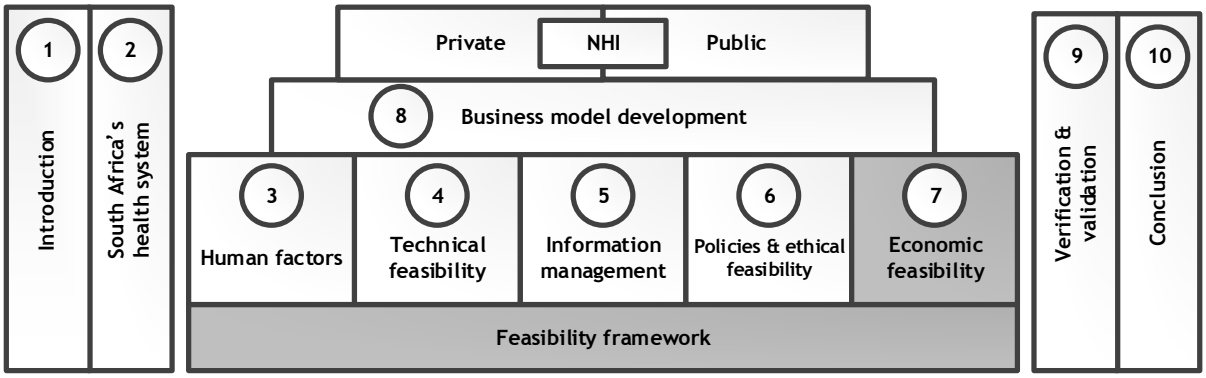
In an interview (APPENDIX G.2), Treurnicht reported that the reality of the NHI is still unsure and that the funding structure is still unclear. She also stated that the current priorities of the DOH regarding the NHI are the national core standards (NCSs), recruitment and information system strengthening in preparation of the NHI. For an mHealth solution to be supported by the DOH, it has to be in line with the DOH's priorities.

6.3 Conclusion

In this chapter the feasibility regarding policy and ethics of an MHSV was investigated. It was found that there are national strategies for eHealth solutions and that they are conducive for an MHSV. Policies regarding the implementation of eHealth solutions are not yet clearly defined and may be problematic if not managed. Information policies exist and are sufficient for an MHSV.

Ethical guidelines on telemedicine services are unclear and would have to be carefully addressed to ensure that the MHSV is approved by ethics boards such as the HPCSA. These same findings apply to the private sector.

CHAPTER 7 ECONOMIC FEASIBILITY



In this chapter the financial factors that influence a mobile health service in South Africa are examined. The key elements of the economic feasibility are cost and funding. The objective of this chapter (RO1.5) is to determine the economic feasibility of an MHSV in South Africa.

The chapter ends with a summary of the results of the entire feasibility framework.

7.1 Health care financing

Expenditure on health in South Africa is characterized by major private expenditure serving a minority of the population (16%) [120]. Health expenditure in South Africa is funded by government and private agencies. Private agency expenditures consist of private health insurance, "out of pocket" and other (e.g. non-profit institutions) [11] [121]. Figures on health expenditure by different agencies are given in Table 7-1.

Table 7-1: Health expenditure in South Africa for 2011 [121]

Agency	Expense
Government	R 120 bn
Private health insurance	R 107 bn
Out of pocket	R 18 bn
Other	R 7 bn

From Table 7-1 it is clear that private health insurance is a large contributor to health expenditure in South Africa. The notable out-of-pocket expenditure shows that individuals contribute to health expenses because either government or private health insurance does not cover all health expenses. These figures show that there are funds available for health projects in South Africa, either in the form of government, private health insurance or out-of-pocket funding.

A report compiled by GSMA in 2011 [11] states that private health expenditure is about 21 times the combined revenue of all South African MNOs. It shows that private health care is expensive and that mobile technology can be incorporated into private health care to reduce health costs. The GSMA

report [11] also states that 43% of the total health expenditure is government funded, coming to about R160 per patient visit. mHealth solutions can be used to reduce this government cost .

Stakeholders with different motives and agendas have to come to an agreement for a large-scale mHealth solution to be sustainable, as highlighted by Kaplan [122]. The questions of effective partnerships and how to achieve scale in a commercially sustainable way were also main discussion topics at the mHealth summit in 2012 [123].

A report on mHealth financing [22] lists the following ways in which mHealth solutions create financial value:

- Prevent sickness thus reducing patients
- Reduce interactions with the health system
- Reduce the number of actions that are carried out
- Reduce the cost of delivery

The main financial value of implementing mHealth solutions is cost reduction.

7.2 National business case

An MHSV is a value-adding service which brings health care to any household with a mobile phone and so increasing access to health care services. It is in line with the objectives of the NHI [23] which include improving access to health care and providing services for the entire population. An MHSV will also improve the data quality of national reports on immunisation, enabling management in the DOH to better administer vaccinations through South Africa and focus on problem areas.

With the introduction of the NHI on its way, more funding will become available for public health care. The case for an MHSV as a value-adding service to the government can be made (Section 6.2.3) in order to procure funding from the government. For the private sector, an MHSV will be a value-adding service to customers and can be developed by an insurance company.

7.3 Cost structure

Osterwalder and Pigneur [21] define cost structures as having the following aspects: fixed cost, variable costs, economies of scale and economies of scope. For the development of an MHSV, fixed cost may consist of the cost of development. The variable cost will be the cost of mobile phones, the cost of transmission, the cost of training and support for health care workers and caretakers.

Economies of scale greatly benefit an MHSV, seeing that the initial development is already built to scale. Scaling increases revenue, with a marginal increase of cost. Economies of scope apply to an

MHSV in that the initial focus on vaccination coverage may be broadened to include a range of additional services, while using the same platform.

The costs that will be discussed in greater detail are the cost of mobile phones, the cost of transmission and the cost of development.

7.3.1 *Cost of mobile phones*

If mobile phones will be provided to health care workers, the cost of mobile phones will be a major cost. Economies of scale may enable the sourcing of mobile phones at a lower cost, but the cost of providing mobile phones will still remain high.

For the general public in South Africa, a mobile phone can be bought with a once-off payment or the cost can be spread over a period of time (usually two years) through a contract agreement. If mobile operators are involved in supplying mobile phones for mobile health projects, mobile phones may be acquired at reduced rates or costs may be absorbed through other methods of funding.

Table 7-2 gives the cost of lower-end mobile phones at different vendors. The table gives prices for the least expensive basic phones, feature phones and smart phone. Basic phones only have voice and SMS capability while smart phones have a wide variety of features including an operating system. Feature phones have less functionality than smart phones but considerably more functions than basic phones.

Table 7-2: Cost of lower end mobile phones from different vendors [124] [125] [126]

Prices for May 2013	Phone type	CellC	Cellucity	Vodacom
Nokia 1282	Basic phone	R 199	-	-
Nokia 100	Basic phone	-	R 199	-
ZTE F900	Feature phone	-	-	R 499
Nokia Asha 201	Feature phone	R 799	R 769	-
Samsung galaxy pocket	Smart phone	R 1119	-	R 899

From Table 7-2 it can be seen that basic phones are considerably inexpensive compared to the entry-level smart phone. Feature phones offer some features of smart phones at a reduced price. The type of phone that is required by a mobile health solution depends on the technology used. If a basic camera is a requirement, feature phones would be sufficient, but if the application is operation-system specific, a smart phone is required.

7.3.2 *Cost of transmission*

In an analysis of technology-enabled health programmes in low- and middle-income countries [62], it was found that about 34% of programmes use voice, almost 32% use applications or other

software and approximately 31% use some form of text messaging service (SMS). A description of available services in South Africa and their respective costs follows.

Voice & SMS

Compared to other African countries, mobile costs in South Africa are high [127]. Prices for the largest mobile operators have settled and have shown relatively little change up to 2012. Table 7-3 lists the costs of different mobile operators for non-contract usage ("pay as you go") at the end of 2012.

Table 7-3: Comparison of MNOs' per second voice costs and SMS costs [128]

	Same SP	Same SP	Other SP	Other SP	Fixed line	Fixed line	SMS	SMS
	Peak	Off peak	Peak	Off peak	Peak	Off peak	Peak	Off peak
Cell C	1.6c	1.6c	1.6c	1.6c	1.6c	1.6c	50c	50c
Virgin Mobile	1.6c	1.6c	4.3c	4.3c	4.3c	4.3c	60c	60c
Vodacom	3.7c	1.9c	4.4c	2.1c	2.1c	2.1c	80c	35c
MTN	4.3c	1.9c	4.6c	2.1c	4.6c	2.1c	80c	35c
8ta	4.5c	1.8c	4.5c	1.08c	1.08c	1.08c	50c	50c

In Table 7-3 "Same SP" refers to costs occurred if a call is made within the same service providers' network. "Other SP" refers to when a call is made to a different service provider (SP). "Fixed line" refers to a call being made to a land line and SMS refers to the cost of sending an SMS (Short Message Service).

From Table 7-3 it is noted that Cell C offers the least expensive cost for transmission of all mobile operators overall. 8ta-costs are less expensive than Cell C for fixed line and other SPs during off peak, but most mobile phones are used during peak hours for the same SP or other SP.

Mass SMS

Bulk SMS is a service that allows a company to send SMSs at a lower premium to multiple mobile phones with various service providers by using an internet platform. There are many such services in South Africa. A comparison in 2012 [129] showed that Panacea Mobile is the least expensive service provider. Costs per SMS range from 24c to 19c, depending on the amount of SMSs sent.

PCM

Please call me (PCM) is a service that allows users to request someone to call them back. This service is provided by all service providers in South Africa and is free of charge, but the mobile operator sets a daily limit on the amount of times the service can be used.

USSD

Unstructured supplementary service data (USSD) is a communication protocol that can be used by most phones to communicate with a service provider's servers. USSD is offered at no cost to end users, but costs are involved in developing and renting USSD services from a mobile operator.

Data

Data over mobile phone networks in South Africa are billed on a per-usage basis. In March 2013 prices among mobile operators per megabyte (MB) of data ranged from 4.95c to 7.8c for data contracts and 15c to 38c outside of data bundles [130]. Fixed packages or "bundles" offer reduced rates for higher usage, but these packages have an expiry date.

In a study on mobile apps in South Africa, 48% of the BoP responded that the cost of data is a limit to using the internet [47]. If an MHSV uses data, then the cost of data should be covered to reach the BoP.

7.3.3 *Cost of development*

If a mobile health service requires the development of a mobile phone application, the cost of developing such an application is dependent on the type of application that is required. Development cost for mobile health services is classified into the following brackets by GSMA [61]:

- Low cost: Foundation app development
- Medium cost: Framework / Bespoke / Once-off app
- High cost: Platform development

A foundation app is an application that is developed to use the mobile operator's framework. A framework refers to software tools and interfaces that can be re-used and evolved for different applications. A platform (e.g. iOS or Android) includes a wide variety of services. The complexity required thus affects the cost of development.

Currently mobile health applications are mostly developed as bespoke apps (63%), while mobile money applications are mostly foundation apps (77%) [61]. A vaccination app will require a framework, and development costs will therefore be higher than a foundational app.

Other costs

Other costs include, among others, ICT software licences, server hosting fees, staff salaries and training costs. The scope of this study is not to provide an economic analysis of the details involved in an MHSV, but rather to identify major factors that need to be considered. These costs should be covered by the revenue or funding generated by the MHSV.

7.3.4 *Cost of service*

Cloud computing is "a set of network enable services, providing scalable, QoS guaranteed, normally personalized, inexpensive computing infrastructure on demand, which could be accessed in a simple and pervasive way" [131]. Cloud services are labelled by using the abbreviation XaaS where X is the service that is provided [132]. Table 7-4 lists a popular classification of cloud services.

Table 7-4: List of cloud services [132]

Service	Definition	Explanation
SaaS	Software as a Service	Uses a single instance of an application to support multiple users.
PaaS	Platform as a Service	Provides developers with an application platform, for the complete program live cycle
IaaS	Infrastructure as a Service	Usage based service for pooled resources
HaaS	Hardware as a Service	Use of scalable datacentres

These services can be linked to the components of a mobile health solution (Figure 4-1).

Popular cloud service providers include Amazon Web Services (AWS), Google Compute Engine, HP cloud, Rackspace, Softlayer and Windows Azure [133]. A website called "PlanForCloud" [133] enables a comparison of costs between different cloud service providers, with different service requirements.

The costing of cloud based services is based on usage, allowing flexibility for increased usage without additional capital investments. With the uptake rate of an MHSV being unknown, cloud based services are ideal for such a solution. APPENDIX B.1 shows the difference in cost between ownership and using cloud services.

Estimating the cost of an MHSV is difficult due to uncertainty of usage traffic. Cloud computing provides flexible pricing that can grow as the solution's traffic increases. In APPENDIX B more detailed cloud serve costs are given for Windows Azure Mobile Services (B.2) and Mobile Applications on AWS (B.3). These services include a PaaS for the MHSV development, and IaaS for the MHSV's database.

Example of costs

The following section gives an example for a web application using a three tier system, namely client, server and database (DB) [133]. The application uses a web interface for clients, and stores information in a database, similar to a MHSV. A 150GB MySQL database is used, with an additional backup database services and a backup storage service. A breakdown of the costs of services for such a web application over three years is given in Table 7-5.

Table 7-5: Year deployment costs for a 3-tier web app example [133]

Year	Server & DB	Storage	Data Transfer	Other Costs	Total
Year 1	R 87 658	R 21 410	R 22 817	R -	R 131 885
Year 2	R 87 658	R 24 298	R 29 263	R -	R 141 219
Year 3	R 87 867	R 27 185	R 35 709	R -	R 150 761
Totals	R 263 183	R 72 893	R 87 788	R -	R 423 865

A comparison of total cost of services is given in Figure 7-1.

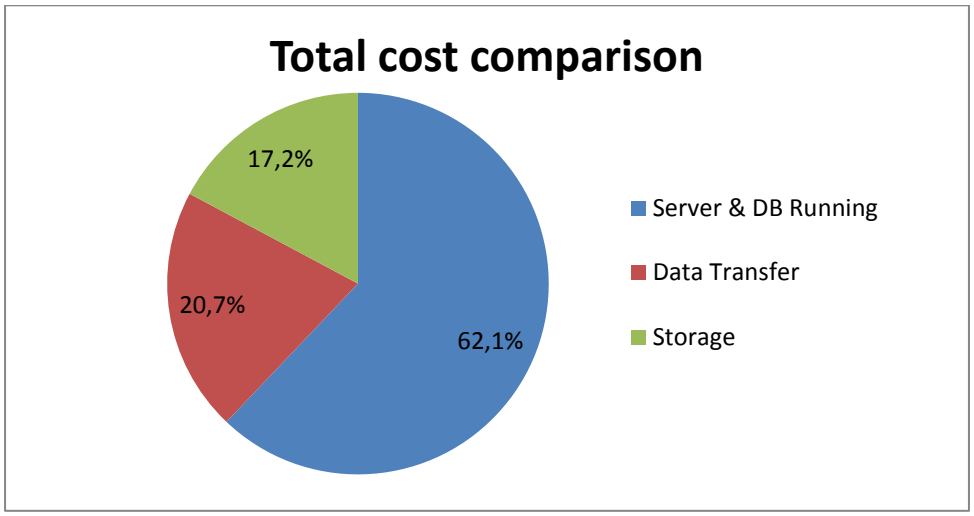


Figure 7-1: Total cost comparison for a 3-tier web app example [133]

The services that make up the costs of such a web application are given in Table 7-6.

Table 7-6: Cloud services for a 3-tier web app example [133]

Servers				
Name	**Cloud**	**Server Type**	**Usage**	**Quantity**
Base web server	Rackspace Rackspace USA	1GB server Linux - On-Demand	24hours/day	10 Patterns
DR server	Aws AWS US-West (Northern California)	m1.small Linux - On-Demand	24hours/day	10 Patterns
Hosting www site	Google Google US	n1-standard-1 Linux - On-Demand	24hours/day	11 Patterns
Load balancer - HAProxy	Rackspace Rackspace USA	1GB server Linux - On-Demand	24hours/day	10 Patterns
Peak web server	Rackspace Rackspace USA	512 server Linux - On-Demand	12hours/day	21 Patterns
Storage				
Name	**Cloud**	**Storage Type**	**Size (GB)**	**Quantity**
Database backups	Aws AWS US-West (Northern California)	S3 Standard	300.01 Patterns	10 Patterns
Hosting www site storage	Google Google US	Cloud Storage Standard	4.00 Patterns	10 Patterns

Databases				
Name	**Cloud**	**Database Type**	**Usage**	**Size (GB)**
DR database	Aws AWS US-West (Northern California)	db.m1.large MySQL - RDS Standard Light-Utilization Large, Reserved 1-Year	24hours/day	3001 Patterns
Main database	Rackspace Rackspace USA	4GB Cloud Database MySQL - Standard Cloud Database 4GB RAM, On-Demand	24hours/day	1500 Patterns
Data transfer				
Source	**Destination**	**Source to destination data/month (GB)**	**Destination to source data/month (GB)**	
Remote Node: Users	Server: Load balancer - HAProxy on Rackspace USA	801 Patterns	4801 Patterns	
Remote Node: Users	Server: Hosting www site on Google US	601 Patterns	3601 Patterns	
Database: Main database on Rackspace USA	Storage: Database backups on AWS US-West (Northern California)	3001 Patterns	3001 Patterns	

7.4 Funding models

An analysis of technology-enabled health programmes in low- and middle-income countries [62] found that there are a variety of funding sources being used. Of the 176 programmes reviewed, 47% relied primarily on donor funding, while 25% received primary funding via out-of-pocket payments (patient fees) and 22% primarily received government funding.

For any mobile service, funding models are generated through different means. With so many players involved in mobile health services, numerous combinations of different funding models are possible. In a presentation by GSMA [61] current funding models for mobile services for developing countries were noted as follows:

Table 7-7: Funding models for mobile services [61]

Model	Description
Consumer (mobile operator led)	Value-adding service for new customer intake
Consumer (non-mobile operator led)	User pays monthly or once-off
Business	Businesses pay for service
Advertising	Advertising through service pays for service
Government	Government funds service
Open Source	External parties adopt and develop service
Donor	Donor organisations fund service

Most of the more than 800 mobile services listed by GSMA make use of a combination of these funding models. Most mobile services include non-MNO-led consumer-based funding models (45%), followed by donor funding (42%) and then by MNO-led consumer funding (36%).

From 2009 to 2012 new mobile services have moved away from donor funding models, with 66% of new mobile services using government funding and 53% using non-MNO-led consumer funding. Funding models for health applications are still mostly donor funded in developing countries, yet consumer, business and open-source funding models have shown growth from before 2009 to 2012 [61].

In a paper on business models for the application market [134], models were categorised as homogeneous or heterogeneous. Heterogeneous revenue models are a mixture of different homogeneous revenue models, while homogeneous models use a single avenue of revenue. Different revenue models for mobile applications are given in Table 7-8.

The type or mixture of revenue models chosen depends on the business model that is ultimately agreed upon. In another study on business models, Ford [135] defined different business models for smartphone applications as given in Table 7-9.

Compared to Table 7-8, Ford's business models follow the revenue models closely, except for the addition of out-of-app purchases and the exclusion of the donation model.

Table 7-8: Revenue models for mobile applications [134]

Revenue model	Description
Free	Free for user, with no direct revenues
Freemium	Free access to limited functionality, payment required for all features
Application purchase	One-time purchase allows unlimited use of application
Advertising	Free for user. Revenue from advertisements in application
Subscription	Time-based fee for use of application
In-app purchase	Application usage is free, yet additional features require payment
Donation	Free for user, but undefined amount can be donated

Table 7-9: Business models for smartphone applications [135]

Type	Description	Revenue model
Free (perpetually)	No cost to user	Large user base is used for in-app advertising
Freemium	Free to use partial version, cost for full version	Entice users to buy complete version
Pay-per-app	Once-off payment for full version	Users make a one-time payment for all features and content
Pay-per-issue	Cost for new version, with old version expiring	Simulate subscription by expiring a version and requiring payment for the new version
In-app purchases	Users can buy additional features within the app	Mostly apps are free, but additional features and content require in-app purchases
Out-of-app activation	Purchase an external account to log into app	Bypassing app payment systems, apps are free for download, but features and content require an account to be purchased outside the app
Out-of-app purchases	Purchase additional features through external account	Allows access to limited features and content, with additional features and content available via outside-app purchases

A report published by Distimo in March 2013 [136] compared the revenue of applications from the Apple App Store for iPhones in February 2013. Revenues from in-app purchase of free apps were the highest, followed by paid apps and then in-app purchase of paid apps. These findings show that the current market favours free applications with in-app purchases.

The market for MHSV is not the same as the market for in-app purchase apps, with many end users not having smartphones. A free MHSV app with in-app purchases may be initially released to generate additional funding. For a national service, additional funding should be acquired via alternative revenue streams, for example government funding.

7.5 Conclusion on economic feasibility

In this chapter the economic feasibility of an MHSV was investigated. It was found that there is a national business case for an MHSV and that the NHI can enable such a solution. Health in South Africa is financed by private and public sources, and an MHSV can reduce costs in both sectors.

The final funding model used for an MHSV should be a combination of funding models with various stake holders. Setting up such value stream may be challenging with so many stakeholders involved.

7.6 Conclusion on feasibility framework

In CHAPTER 3 to CHAPTER 7 the different aspects of the feasibility framework was investigated. The results are summarised in Table 7-10 through the use of colours. The feasibility of a certain aspect is indicated as follows: Sufficient, Manageable, Challenging.

Table 7-10: Feasibility dashboard for an MHSV in South Africa

	Micro-level	Meso-level	Macro-level
Human factors	Caretakers	Health care workers	Management
Technical	Mobile phones & software	Mobile network infrastructure	Health information system infrastructure
Information management	Information capturing	Information integration	Information system
Policies and ethics	Ethical aspects	Regulation of information and apps	National strategies
Economic	Costs & funding	National business case	Health financing

Table 7-10 gives the five areas of feasibility that were investigated across three levels of scale. No aspect investigated would make an MHSV unfeasible, but there are challenging areas and areas that have to be taken into consideration. The greatest challenges for an MHSV's feasibility lie in the areas of human factors, information management and economic factors.

Refer to 0 for a SWOT (strength weakness opportunities and threats) analysis of an MHSV in South Africa.

7.6.1 *Human factors*

Public

Even though most caretakers in the public sector are expected to have access to mobile phones [47], demographic factors such as age [49] and social factors such as population movement and AIDS orphans (APPENDIX G.2) should be taken into consideration in the development of an MHSV. These factors may challenge the effectiveness of an MHSV if not addressed.

Mobile phone literacy [36] [49] and the work environment (APPENDIX G.2) (APPENDIX I) for health care workers can challenge the implementation of an MHSV. Health care workers would require training [56], and an MHSV should address the work culture regarding mobile phones. Management may oppose the introduction of a new system. Thorough change management is needed on a human level to ensure an MHSV's success.

Private

For the private sector, caretakers are expected to have higher mobile phone literacy than public caretakers due to higher income and mobile phone ownership [47]. Challenges regarding mobile phone usage with older caretakers are still expected [49].

Health care workers in the private sector are likely to be more skilled than those in the public sector. Challenges with mobile phone literacy are still expected due to the age of health care workers. Management may also lack skills to analyse data and incorporate information into management systems [59].

7.6.2 *Technical*

Public

South Africa has a sufficient mobile and health infrastructure to support an HMSV. The lack of computers in the lower levels of the public sector can be circumvented by the use of mobile phones. Even though many South Africans own a mobile phone and most have access to mobile phones, the usage of mobile phones by health care workers is critical and some mobile phones may need to be sponsored.

Private

The availability of mobile phones, mobile software and mobile network infrastructure in the private sector is similar to the public sector. Regarding the health information system infrastructure, the private sector have better ICT infrastructure [26].

7.6.3 *Information management*

Public

The DHIS provides information management on a district level, but there are multiple systems (or none) on lower levels. Where overlapping information management systems exist, MHSV integration will be required. The quality of information captured is a challenge, and measures need to be taken to ensure that data entered into the MHSV are complete and accurate.

A case study showed that the information management system of an MHSV is feasible.

Private

The private sector has functional information management systems. Integration into these systems can also be managed. Quality of data may be better due to routine electronic reporting for compensation. Information quality still has to be ensured for the MHSV and it is thus labelled as a challenge.

Regarding the information system, the findings of the case study apply to the private sector as it does in the public sector.

7.6.4 *Policies and ethics*

Public

It was found that there are national strategies for eHealth solutions which are conducive for an MHSV. Policies regarding the implementation of eHealth solutions are not yet clearly defined which may be problematic if not managed. Information policies exist and are sufficient for an MHSV. Ethical guidelines on telemedicine services are unclear and should be managed to ensure that the MHSV is approved by ethics boards such as the HPCSA.

Private

The same policies and ethics apply to the private sector as it does in the public sector.

7.6.5 *Economic*

Public

Public health care is funded by government, and the introduction of the NHI provides an opportunity for the funding of an MHSV. Because mHealth solutions can reduce the cost of health care, a national business case can be made that an MHSV will extend the reach of health care and improve information management.

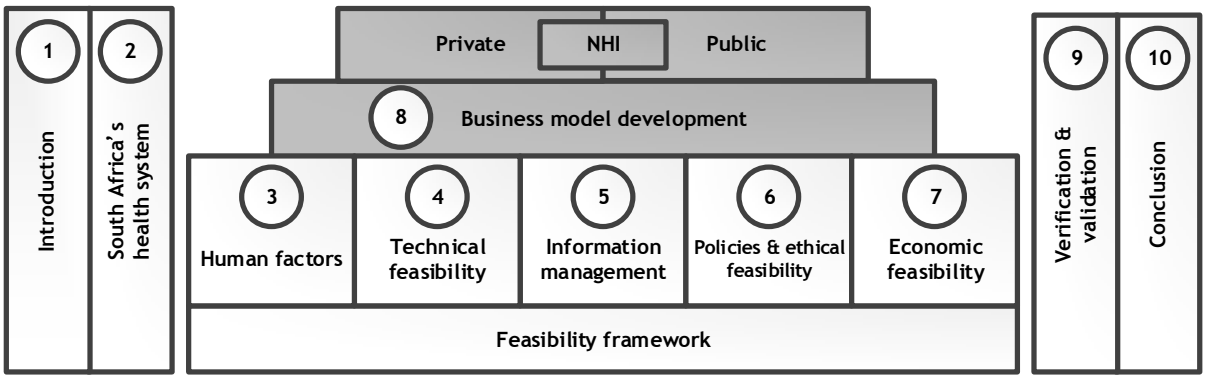
Various funding methods for an MHSV are possible, but the complexity of partnership involvement may present a challenge. This complexity together with the various costs that need to be covered makes the economic feasibility of an MHSV a challenge.

Private

Private health care is ultimately funded by individual patients. mHealth solutions can be applied to reduce health care costs. A national business case can be made according to which a health insurance provider funds an MHSV. The introduction of the NHI will affect the business model for an MHSV in the private sector. Forming an economically viable MHSV with many stakeholders involved will be challenging.

SECTION 2 BUSINESS MODELS

CHAPTER 8 BUSINESS MODEL DEVELOPMENT



In this chapter, business models for an MHSV in South Africa are proposed. The definition of a business model is discussed first, followed by a description of Osterwalder's canvas for business models [21]. Osterwalder's canvas is then applied to an MHSV, after which a business model is proposed in conclusion.

The objectives of this chapter are to develop business models for an MHSV in South Africa (RO2) and to determine the effect that the NHI will have on an MHSV (RO3).

8.1 Business model defined

Zott *et al.* [137] reviewed 103 publications on business models and found common themes for using one:

1. It is a method of analysing a firm or network.
2. It explains business operations holistically on a systems level, both the what and the how.
3. It describes business activities of a local firm as well as those of outside suppliers, partners or customers.
4. It defines how value is created and captured

Zott *et al.* [137] found that the reviewed literature developed largely in isolation and there is no agreement on the definition of a business model. The above-mentioned list describes the areas of application and themes of business models but it does not say what a business model is. Among the components of business models discussed, the concept of value was the most prevalent, but no further agreement was found.

To clarify the concept of a business model, Zott *et al.* [137] proposes that each study should indicate the analytical purpose behind using a business model, for example:

- A business model as a description of e-business models
- A business model as an activity system describing boundary-crossing activities
- A business model as a cost/revenue structure for commercialising technological innovations

By stating the analytical purpose of using a business model, the definition of a business model specific to the given study is clarified.

8.2 Business model canvas

Chen *et al.* [138] reviewed the business models of eight successful telemedicine ventures by using Osterwalder and Pigneur's business model canvas [21] to describe each telemedicine service. The reasons given by Chen *et al.* [138] for using the business model canvas for telemedicine business models are as follows:

1. It describes both the activity systems and cost/revenue architectures.
2. It uses value creation as a basis.
3. It describes how value is delivered and captured.
4. It reflects the current consensus in business model conceptualisations.

Osterwalder and Pigneur [21] define a business model as follows: "A business model describes the rationale of how an organization creates, delivers and captures value". Osterwalder and Pigneur's business model canvas [21] has been applied worldwide and is used in organisations such as IBM, Ericsson, Deloitte, government services of Canada and others.

The business model canvas was developed by Osterwalder and Pigneur [21] as a tool for describing, analysing and designing business models. The business model canvas describes a business model though nine building blocks (elements) that show the method though which a company intends to make money, as described in Table 8-1.

These elements encompass the four key areas of business: customers, offering, infrastructure and financial viability [21]. These elements are presented graphically in the business model canvas as in Figure 8-1.

Table 8-1: Elements of a business model [21]

Element	Description
Customer Segments	Which customers are served, with specific needs
Value propositions	How value is created via addressing a problem or need
Channels	Interfaces through which value is delivered to customers
Customer relationships	The type of relationship with each customer segment
Revenue streams	Ways in which cash are generated via different pricing mechanisms
Key resources	Resources required to do business
Key activities	Activities required to offer value proposition
Key partnerships	Alliances with outside parties for mutual benefit
Cost structure	Major costs for business operation

<table>
<tr><td rowspan="2">Key partners</td><td>Key activities</td><td rowspan="2">Value proposition</td><td>Customer relationships</td><td rowspan="2">Customer segments</td></tr>
<tr><td>Key resources</td><td>Channels</td></tr>
<tr><td colspan="3">Cost structure</td><td colspan="2">Revenue streams</td></tr>
</table>

Figure 8-1: The business model canvas [21]

Evaluating the business model canvas

Osterwalder and Pigneur's business model canvas is value-centred by definition [21] – one of the most prevalent components of current business according to Zott *et al.* [137]. It also follows Zott *et al.*'s [137] four general themes of business models:

1. New unit of analysis: Analyses how a firm does business, as has been demonstrated by the analysis of eight telemedicine services by Chen *et al*. [138].
2. System-level concept: Describes what an organisation does through the value proposition and how business is done by including channels, customer relationships, revenue streams, key resources and key activities.
3. Activity centred: Includes the key activities of an organisation, describing activities that are required by each business segment.
4. Value focused: Defines a business model according to value, with the value proposition being a key element in the business model canvas.

This list shows that the business model canvas is relevant to current uses for business models.

Depending on the analytical purposes, the business model canvas can be used to describe:

- E-business models – through channels, value proposition, customer relationships and key activities
- Boundary-crossing activity systems – through key activities, channels and key partnerships
- Cost/revenue structures for commercialising technological innovations – through cost structure, revenue streams and value proposition.

The business model canvas is clearly a flexible tool that can be used for a variety of analytical purposes to describe the operations of a business in a variety of ways.

8.3 Business model canvas applied

As required by Zott *et al*. [137], the analytical purpose behind using a business model for an MHSV needs to be identified. In this study, a business model is used for the purpose of describing the cost/revenue structure and economic mechanisms for the commercialisation of such a service. The business model canvas [21] is used because it is able to describe the cost/revenue structure whilst elaborating on the context and manner in which business is done. The business model canvas is applied to an MHSV by reviewing each element in the light of the feasibility framework of the preceding chapters.

8.3.1 *Customer segments*

Different customers have different needs, and customer segments help define customers according to their needs. The types of customer segments are mass market, niche market, segmented, diversified and multi-sided platform or market [21].

The customer segments for an MHSV are multi-sided platforms or markets. For an MHSV to function, a variety of customers is required, e.g. caretakers, health care workers, management (0), companies (e.g. mobile operators and health insurance) and government.

The customers for telemedicine services in developed countries were found to be mainly companies, whereas in developing countries customers are individuals [138]. In South Africa, the customer focus will be on individuals (caretakers) but also include companies.

8.3.2 *Value propositions*

Value propositions create value for a customer segment by addressing problems or satisfying needs. Value propositions can be innovative, with a new or disruptive offer, or they can add to an existing market offer with additional features and attributes. Value can be created through: newness,

performance, customisation, “getting the job done”, design, brand/status, price, cost reduction, risk reduction, accessibility and convenience/usability [21].

The value of an MHSV includes newness, performance, brand/status, risk reduction, accessibility and convenience/usability. The greatest value to a caretaker is accessibility to health information. The value for government is the prevention of disease [139], increased accessibility to health data (Section 5.3) and the possibility to determine vaccination distribution. For mobile operators the value is increased brand awareness and for health insurance companies the value is user statistics.

The value of telemedicine services in developed countries is convenience, while for developing countries it is price (reducing travel time and expenses) [138]. The main value of an MHSV in South Africa is access to health information rather than price.

8.3.3 *Channels*

Channels are the interfaces with customers through which the value proposition is delivered. The phases of channels are awareness, evaluation, purchase, delivery and aftersales. The types of channels are a company’s sales force, web sales, own stores, partner stores and wholesalers [21].

For an MHSV, all channel phases and all types of channels except wholesalers are relevant. Sales force refers to sales teams that go into communities and sell the service to customers. Web sales are sign-ups that take place via the official website. Own stores are health facilities with vaccination services, while partner stores are channels through which awareness can be increased, such as pharmacy chains, a mobile operator or health insurance companies.

ICT and Internet access were found to be critical enablers for telemedicine services [138]. Most South Africans have access to mobile phone networks [84] and the Internet [66] via their mobile phones, showing that ICT and Internet access is available for an MHSV in South Africa. Mobile networks and the health information system (CHAPTER 4) can be used to provide the channels.

8.3.4 *Customer relationships*

Customer relationships refer to the type of relationship that is established with each customer segment. The relationship is motivated by customer acquisition, retention and boosting sales. Types of relationships include: personal assistance, dedicated assistance, self-service, automated service, online communities and co-operation [21].

An MHSV would include personal assistance, self-service, automated service and online communities. Health information content will not be created through co-operation but rather from respected sources.

Telemedicine services mostly include personal assistance relationships. However, there is a distinction between dedicated and non-dedicated personal assistance. Non-dedicated assistance is less expensive than dedicated assistance while dedicated assistance form a stronger customer relationship over time. Some services, like tele-psychology, benefit the most from dedicated assistance, while other services may not require dedicated assistance. [138]

Dedicated assistance is not necessary for an MHSV, seeing that most caretakers do not receive maternal care from the same nurse due to nurse time scheduling. Customer relationships take place via self-service and automated service that can be accessed through caretakers' mobile phones.

8.3.5 *Revenue streams*

Revenue streams are the ways in which cash is generated from customer segments, with different pricing mechanisms. Ways to generate cash include asset sales, usage fees, subscription fees, leasing, licensing, brokerage and advertising [21]. Income also has to be generated from telemedicine services by government funding for health statistics [138].

The revenue streams for an MHSV are advertising, subscription fees and brokerage. With such a large user base, advertising is a viable source of income. Subscription fees for additional features during the use of the service can generate additional funds. Brokerage fees could be generated from selling statistics to government and health insurance companies. Funding models were also discussed in Section 7.4.

Patients tend to be more willing to pay for telemedicine services in developing countries [138]. The following payment methods for telemedicine services were found to be prominent: pay per service, pay per membership, pay per treatment and franchising. Convenience of payment is also possible through integration with mobile operator payment.

Because of the number of stake holders involved with an MHSV, it is possible to generate income through a combination of various funding models. Caretakers can pay subscription fees, mobile operators can provide reduced tariffs, companies can advertise on mobile phones and government and other companies can supply funding for statistics on health.

8.3.6 *Key resources*

Key resources are different types of resources required to do core business are physical, financial, intellectual and human [21]. For an MHSV, physical resources are mainly ICT infrastructure, including mobile phones and servers. Human resources needed include staff for health worker training, program roll out, and ICT support and development.

Physical resources for telemedicine services should be portable and accessible [138]. An MHSV is based on mobile phones and Internet based services, which makes all services and resources portable and accessible.

Health care workers were discussed in Section 3.2 and ICT infrastructure was discussed in Section 4.4.

8.3.7 *Key activities*

Key activities are the most important activities related to production, problem solving or the platform/network in order to offer a value proposition [21]. The key activity for an MHSV is to provide a platform that facilitates information transactions through various portals, be it a mobile application or website. For this platform to be used, marketing, training and support are also needed. (See Figure 5-1 for an example of such a platform.)

For telemedicine services, all successful ventures have peripheral activities in addition to the main activity [138]. In developed countries, these activities help companies reach more customers and in developing countries they help with geographical and infrastructure constraints. For an MHSV additional activities would involve delivering value-adding services to different stakeholders. These activities will enable reaching more customers.

In a review of telemedicine business models, all but one venture had both economic and social goals [138]. An MHSV in South Africa not only has to be economically feasible but has to address social needs of caretakers as well.

8.3.8 *Key partnerships*

Key partnerships are alliances that are formed for optimisation and scale, reducing risk and uncertainty, and gaining resources and activities. Types of partnerships include strategic alliances, coopetition, joint ventures and buyer-supplier relationships [21].

For an MHSV, alliances will be formed with government, a mobile operator and health insurance companies. A government alliance provides scale, resources and activities in terms of nationwide human resources. A mobile operator alliance provides resources in terms of ICT infrastructure and network services. Alliance with health insurance companies provides scale for marketing to customers.

In developing countries, three quarters of ventures are privately held, funded mostly through non-government means [138]. An MHSV in South Africa should aim to gain funding from patients and other means rather than having government as the primary funding source.

8.3.9 *Cost structure*

The cost structure reflects the most important costs for business operation. Cost models range from cost-driven to value-driven models. Cost structures include fixed costs, variable costs, economies of scale and economies of scope [21].

An MHSV is value driven yet cost effective enough to reach as many caretakers as possible. The most important costs are for development, technical support and training health care workers. The various costs are discussed in Section 7.3.

8.4 Proposed business models

In this section, the business model canvas will be used to propose a business model for an MHSV. The public and private sector will be treated separately at first, because they not only differ in terms of revenue streams but in business operation as well.

The introduction of the NHI (National Health Insurance) creates a common revenue stream (among others) for the private and public health sector, with the opportunity of integrated services. The effect of the NHI on the business models is therefore discussed at the end of the section.

8.4.1 *Business model patterns*

Osterwalder and Pigneur [21] identified the following business model patterns when using the business model canvas to map out a business' value creation process:

- Unbinding business models
- The long tail
- Multisided platforms
- Free as a business model
- Open business models

For an MHSV, the "free as a business model" pattern is most relevant. Examples of this pattern are [21]:

- Advertising: Fees for ad space
- Freemium: free limited subscription pro-account
- Open Source: subscription for updates and service support
- Bait and hook: Initially inexpensive or free; further subscription

As discussed in the previous chapter, revenue generation from advertising or Freemium can be used for an MHSV. The advertising business model pattern is summarised in Figure 8-2 by using the business model canvas, while the Freemium business model pattern is summarised in Figure 8-3.

<table>
<tr><td rowspan="2">Key partners</td><td>Key activities
Platform development
Maintenance</td><td rowspan="2">Value proposition
Ad space
High frequency

Product or service</td><td>Customer relationships</td><td rowspan="2">Customer segments
Advertisers
Customers</td></tr>
<tr><td>Key resources
Platform</td><td>Channels</td></tr>
<tr><td colspan="3">Cost structure
Platform costs
Customer acquisition costs</td><td colspan="2">Revenue streams
Ad fees
Free</td></tr>
</table>

Figure 8-2: Business model pattern for advertising [21]

In Figure 8-2 only key elements of the business model pattern for advertising funded product or service is given. Colours are used to group the following concepts across the canvas: Advertising, Platform, Customers. The following describes how a business operates that is based on the business model pattern for advertising.

Advertisers pays ad fees for ad space and gain a high frequency of ad hits. The platform is a key resource of a business that is used to develop and maintain the product or service with the ad space included. To sustain the platform and acquire customers, certain costs such as development costs and marketing costs need to be covered by the business. The end customer of the product or service, which carries the ad space, is able to acquire the product or service for free, due to the cost being covered by the advertisers.

<table>
<tr><td rowspan="2">Key partners</td><td>Key activities
Platform development</td><td rowspan="2">Value proposition
Basic product or services
Premium product or services</td><td>Customer relationships</td><td rowspan="2">Customer segments
Casual user
Dedicated user</td></tr>
<tr><td>Key resources
Platform</td><td>Channels</td></tr>
<tr><td colspan="3">Cost structure
Platform development costs</td><td colspan="2">Revenue streams
Free account
Subscription</td></tr>
</table>

Figure 8-3: Business model pattern for Freemium [21]

Colours in Figure 8-3are used to group the following concepts across the canvas: Casual user, Platform, Dedicated user. Only key elements of the business model pattern for a Freemium

product or service is given. The following describes how a business operates that is based on the business model pattern for Freemium.

When using Freemium, a basic service or product is offered at no cost to casual users. Once users use the product or service more regularly and desire more functionality, they can become a dedicated user by gaining a premium product or service as the cost of a subscription. The revenue from subscriptions of dedicated users is used to cover the cost of the platform, which is used to provide the service or product.

The above business model patterns are useful to an MHSV, and will be included in the proposed business models. An MHSV does not have to be limited to one specific pattern but can include a combination of patterns.

8.4.2 *Public business model*

In Figure 8-4 a business model for an MHSV in the public sector is proposed. The key customers are advertisers, caretakers, a mobile operator and government.

<table>
<tr>
<td rowspan="2">Key partners
Mobile operator
Government</td>
<td>Key activities
Platform development & maintenance
Marketing
Training & support</td>
<td rowspan="2">Value proposition
Brand awareness of products or services
Access to health information & support
Increased mobile user base subscriptions
Improved information management
Prevention
Distribution prediction</td>
<td>Customer relationships
Self-service
Automated service</td>
<td rowspan="2">Customer segments
Advertisers
Caretakers
Mobile operator
Government</td>
</tr>
<tr>
<td>Key resources
ICT infrastructure
Human resources</td>
<td>Channels
Sales force
Health facilities
Mobile operator</td>
</tr>
<tr>
<td colspan="3">Cost structure
Platform development & maintenance
Health worker training & support
Population awareness & training</td>
<td colspan="2">Revenue streams
Advertising
Free / Pay for more features
Brokerage of statistics to government
Reduced mobile operation cost</td>
</tr>
</table>

Figure 8-4: Proposed business model for an MHSV in the public health sector

The following colours are used to group the concepts related to the customers across the canvas in Figure 8-4: Advertisers, Caretakers, Mobile operator, Government. Each segment of the business model is discussed further.

Revenue is generated from advertising to the caretakers through the service. Products from advertisers can create awareness in a specific market of caretakers (e.g. baby products for those with infants). Health statistics are brokered to the government (a key partner), with the government getting value from improved information management, prevention of sickness and vaccination distribution prediction.

The value for caretakers is that they gain relevant information regarding their child's health as well as support in terms of health information. Basic features are available for free, while a premium version with more features can be bought. Customer relationships with the caretakers will include self-service and automated service.

Mobile operators (a key partner) can be involved to reduce mobile usage costs for caretakers. A Mobile operator can benefit from an MHSV by gaining customer subscriptions if the MHSV is presented as an exclusive value-added service. Payment for the service (or app) can be done through

the mobile operator. Service can be pay-as-you-go or an addition to a new or existing handset subscription.

Channels used to deliver the service will be mainly through mobile operators, but will also be at the health facility (recording of data). A sales force will be used to gain customers for the service via public channels and mobile operators as well as at health facilities.

One of the major costs for the MHSV is the development of the platform and maintaining the platform during service. Another cost is to train and provide continual support for health care workers to use the MHSV. Creating public awareness (via marketing) and training for caretakers will also incur costs.

From the proposed business model, it can be seen that many stakeholders are involved and value can be created for each stakeholder. By generating value for a variety of stakeholders, it may be possible to offer the service to caretakers at no cost or at reduced subscription fees.

8.4.3 *Private business model*

The application of the business model canvas to an MHSV for the private sector is summarised in Figure 8-5.

The difference in the business model for the private sector (Figure 8-5) vs. the public sector (Figure 8-4) is that the role of the government is taken over by health insurance companies. The benefit for health insurance is that they gain a value-adding service for their customers. Additionally, health statistics can also be brokered to them.

Because private caretakers have greater access to internet, there is an additional customer relationship in the form of an online community. Other stakeholders function similarly to the business model proposed for the private sector.

<table>
<tr>
<td rowspan="2">Key partners
Mobile operator
Health insurance companies</td>
<td>Key activities
Platform development & maintenance
Marketing</td>
<td rowspan="2">Value proposition
Brand awareness of products or services
Access to health information & support
Increased mobile user base subscriptions
Value added service for health insurance</td>
<td>Customer relationships
Self-service
Automated service
Online communities</td>
<td rowspan="2">Customer segments
Advertisers
Caretaker
Mobile operator
Health insurance company</td>
</tr>
<tr>
<td>Key resources
ICT infrastructure
Human resources</td>
<td>Channels
Sales force
Health facilities
Mobile operator
Health insurance</td>
</tr>
<tr>
<td colspan="2">Cost structure
Platform development & maintenance
Health worker training & support
Population awareness & training</td>
<td colspan="3">Revenue streams
Advertising
Free / Pay for more features
Brokerage of statistics to health insurance
Reduced mobile operation cost</td>
</tr>
</table>

Figure 8-5: Proposed business model for an MHSV in the private health sector

The following colours are used to group the concepts related to the customers across the canvas in Figure 8-5: Advertisers, Caretakers, Mobile operator, Health insurance company.

8.4.4 *Effect of national health insurance*

The national health insurance (NHI) aims to give the public access to private health care facilities and increase available funding for public health care (see Section 6.2.3 for further details). With the NHI still under discussion, final detail on its funding structure is not certain. The prediction on the effects of the NHI on an MHSV is based on the following assumptions:

- Opportunity: That the NHI creates an opportunity for an MHSV, e.g. providing an MHSV for PHC outreach teams
- Funding: That funding for an MHSV can be secured within the NHI financial structure
- Outsourcing: That private health care is involved in providing immunisation services
- Mandatory: That coverage under NHI is mandatory for all South Africans.

A business model for an MHSV with both the public health sector and the private health sector participating in the NHI is given in Figure 8-6.

<table>
<tr>
<td rowspan="2">Key partners
Mobile operator
Government
Private health care</td>
<td>Key activities
Platform development & maintenance
Marketing
Training & support</td>
<td rowspan="2">Value proposition
Brand awareness of pharmaceuticals / products
Access to health information & support
<s>Increased mobile user base subscriptions</s>
Improved information management
Prevention
Distribution prediction</td>
<td>Customer relationships
Self-service
Automated service
Online community</td>
<td rowspan="2">Customer segments
Advertisers
Caretakers
<s>Mobile operator</s>
Government</td>
</tr>
<tr>
<td>Key resources
ICT infrastructure
Human resources</td>
<td>Channels
Sales force
Health facilities
Mobile operator
Private health care</td>
</tr>
<tr>
<td colspan="3">Cost structure
Platform development & maintenance
Health worker training & support
Population awareness & training</td>
<td colspan="2">Revenue streams
Advertising
Free / Pay for more features
Brokerage of statistics to government
<s>Reduced mobile operation cost</s>
NHI funding</td>
</tr>
</table>

Figure 8-6: Proposed business model for an MHSV for public and private participating in NHI

In Figure 8-6, additions to the public business model (Figure 8-4) are highlighted. Private health care is included as partners and channels. No additional value proposition is provided for private health care seeing that they will already make use of NHI funding and the NHI's client base.

With the mandatory use of NHI, every citizen will receive an NHI card that will cause the need for more effective information management. An MHSV can address this need and provide a scalable solution for the entire population of South Africa. NHI funding will include the brokerage of statistics to the government.

With such a large reach, revenue from advertising will significantly increase. A paid version can still provide additional features. The online community from the private business model is included because more users will have internet access.

If the MHSV is made mandatory by government, a single mobile operator can't provide the service because of the Competition Act. The effect is that mobile operators will not provide reduced costs for the MHSV in order to gain customers.

8.5 Considerations

In this section, feedback is given from interviews regarding the business models.

Treurnicht (APPENDIX G.2) stated that she was not an expert on business models but commented on the inclusion of the NHI in the business model, saying that the NHI is still unsure. She advised that such a model would only be relevant if the assumptions regarding the NHI were to be realised in the future.

Goosen (APPENDIX G.3) noted that the value proposition of the business models should be refined more to include incentivising strategies. He also suggested developing separate business models for an USSD-based MHSV for the majority of users and an app-based MHSV for the rest. For the USSD service, in-app advertising could pose challenges.

Goosen also noted that the business model will be more comprehensive if they are refined and elaborated on. Evidence has to be obtained to show the need and efficacy of an MHSV. A cost analysis for the MHSV should include the major costs of integration and include a detailed breakdown of costs for technical and logical integration into the existing ICT infrastructure.

Fortuin (APPENDIX G.5) commented that government seldom has funding available, thus pharmaceutical companies and large organisations (e.g. the UN) should be included in the business models.

8.6 Implementation

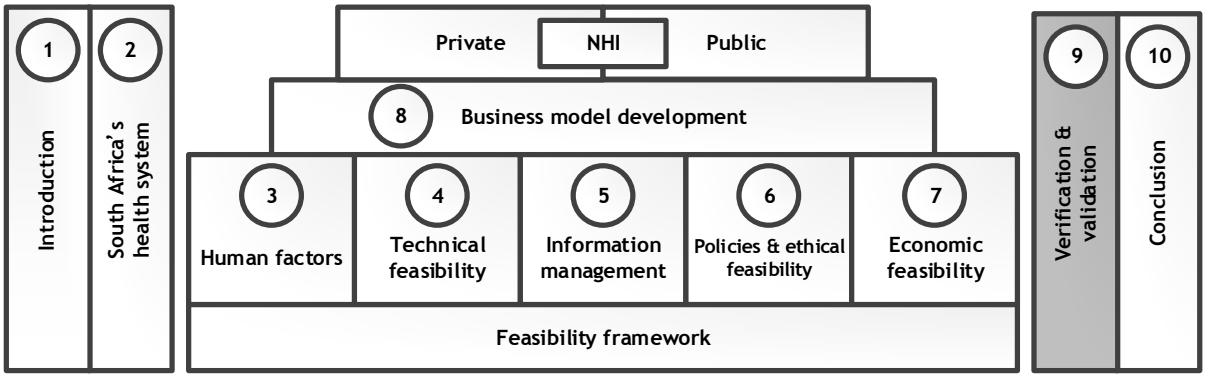
The implementation of these business models requires a client that will provide funding for the development of the MHSV. Discussions with relevant regulatory bodies have to be initiated and key partnerships have to be established. End-user surveys and a complete economic analysis also have to be conducted.

Change management on all levels will be critical in the development of the MHSV, and buy-in from the DOH should be secured from the start. An MHSV requires the buy-in from multiple stakeholders and it is vital to procure it before development can be started.

8.7 Conclusion

In this chapter the business model canvas was used to develop business models for an MHSV both for the public sector and the private sector. The effect of the NHI was incorporated into a third business model. The creation of business models showed how an MHSV can be made economically feasible through value creation and revenue streams (RO1.5).

CHAPTER 9 VERIFICATION & VALIDATION



In this chapter the research done in this paper is verified and validated. Verification considers whether the design intent of the research outputs was met while validation concerns the credibility of the research process both internally and externally.

Most research studies evaluating mHealth initiatives have been conducted in developed countries, even though the majority of mobile phone users live in developing nations [140]. There is evidence both for and against mHealth initiatives in developing countries, but convincing evidence is lacking [122] [140]. This gap in research on mHealth initiatives in developing countries such as South Africa makes research challenging. To bridge the gap in research, additional sources such as case studies, surveys and interviews are used in this study.

The objectives of this chapter are to verify the research outputs (RO4), primarily the feasibility framework and business model, and validate the research process (RO5) presented in the previous chapters. The design requirements are used as criteria for the verification of the business models. The research objectives and corresponding research methods are shown again in Table 9-1.

Table 9-1: Review of research objectives covered by research methods used (same Table 1-4)

Method		RO1: Feasibility	RO2: Business models	RO3: NHI	RO4: Verification	RO5: Validation
Feasibility framework:	Literature study	X	–	X	X	X
	Surveys	X	–	–	X	–
	Case study	X	–	–	X	–
Business model development		X	X	X	X	X
Structured Interviews		X	X	X	X	X

9.1 Structured interviews

Interviews are used to strengthen the verification of the research method and results and to provide validation. For this study, interviews are primarily used to validate the research externally (RO5), but

also to verify research findings (RO4). Information from the interviews is also used to support RO1, RO2 and RO3. Mouton [141] identifies different types of interviews that are used in research:

- Structured self-administered questionnaires
- Structured telephonic interviewing
- Semi-structured focus-group interviewing
- Free-attitude interviewing

Patton [142] identifies the following types of interviews:

- Informal conversational interview
- Interview guide approach
- Standardised open-ended interviews
- Closed quantitative interviews

Patton [142] also discusses the strengths and weaknesses of each type of interview. The strength of informal conversational interviews is that information of high relevance to a specific field arises from the interviews. The weakness of such interviews is that data organisation and analysis can be difficult. In closed quantitative interviews many prepared questions can be answered, with easy data organisation and analysis [142]. The weakness is that these interviews can be irrelevant and distort responses because of limited choices. Interview guide approach and standardised open-ended interviews lie between these extremes.

With the aim of validating and verifying research in mind, similar questions need to be asked to be able to compare responses. Also, respondents need some degree of freedom in responses to give additional content that was not considered. The type of interview that best suits the aims of using an interview in this study is thus a standardized open-ended interview. It allows respondents to provide additional feedback regarding the research that has not been considered, but provide sufficient comparability of responses for verification and validation.

9.1.1 *Interview participants*

The participants in the interviews and their details are listed in the following table.

Table 9-2: Credentials of interviewees for research validation

Interviewee	Position	Field of work
Ryan Goosen	Development at Wigroup	Mobile phone apps for payment and rewards
Miekie Treurnicht	Analyst at BroadReach Health care	National projects for health access improvement – Health Systems Strengthening
Casper Strydom	Solutions Architect Mezzanineware	Mobile clinical and administrative decision support systems
Jill Fortuin	MRC director Telemedicine mHealth (until 2013) & ICT4H / ehealth Secretariat Director	Projects with the Department of Health that use ICT to provide and support health care activities & training for ICT4H (ICT for Health)

These participants were chosen for their expertise in the fields of health care and mobile phone solutions. The following table lists the relevant experience of each interviewee.

Table 9-3: Expertise of interviewees for research validation

Interviewee	Expertise
Ryan Goosen	Technical knowledge of mobile solutions and mobile business solutions.
Miekie Treurnicht	Knowledge of current state of public health care, knowledge of working of the department of health, and involved in current public health care projects
Casper Strydom	Part of development of various mobile solutions for health care, knowledge of government approval process, and implementation of mobile health solutions
Jill Fortuin	Knowledge of mobile health projects, internal working of department of health, current affairs of health care in South Africa, and health care project implementation

9.1.2 *Interview questions*

The following questions were posed to participants to evaluate the results from this research:

Regarding the feasibility framework:

1. Is the feasibility study comprehensive in the areas covered?
2. Are the results from the feasibility study accurate?
3. Are the results relevant to the current industry?
4. Can the results be used to make general statements or infer principles beyond the research context?
5. General comments?

Regarding the business models:

1. Is Osterwalder's business model canvas a relevant model to use?
2. Is it clear how value is created in each business model?
3. Are the descriptions used in the business models accurate?
4. Are the business models relevant to the current industry?
5. Are the business models comprehensive?
6. Can the results be used to make general statements or infer principles beyond the research context?
7. General comments?

9.1.3 *Interview Process*

An information sheet was e-mailed to respondents before the interview to allow them to familiarise themselves with the results from the study. The information sheet contained the research design (Section 1.3), the feasibility dashboard with discussion (Section 7.6) and the proposed business models (Section 8.4).

The greater part of each interview was recorded, while the most relevant sections of the responses were transcribed. When recording interviews was not possible, written responses were obtained. Responses are given in APPENDIX G.

9.2 Verification

The purpose of verification is to evaluate whether the research objectives have been met (RO4). The research has been divided into three parts, namely feasibility (RO1), business models (RO2) and NHI (RO3). The following sections evaluate each of these.

9.2.1 *Feasibility*

The feasibility of an MHSV was determined through using the feasibility framework, business model development and interviews. The primary research objective (RO1) was reached through the secondary research objectives of each feasibility area (RO1.1 – RO1.5).

Feasibility framework

At the end of each chapter of the feasibility framework (0 - CHAPTER 7), the conclusion summarises whether the research objective for each feasibility area (RO1.1 – RO1.5) was reached. In Section 7.6, conclusions from the feasibility framework are summarised in the feasibility dashboard (Table 7-10). The conclusions determined the feasibility in each area and fulfilled each corresponding research objective. Table 9-4 shows where in the study each of the objectives was reached.

Table 9-4: References to where research objectives of feasibility framework were met

Research Objective	Reference
RO1: Feasibility – Determine the feasibility of an MHSV in South Africa.	7.6
RO1.1: Determine the feasibility regarding human factors	3.5 & 7.6.1
RO1.2: Determine the technically feasibility	4.5 & 7.6.2
RO1.3: Determine the information management feasibility	5.5 & 7.6.3
RO1.4: Determine the feasibility regarding policies and ethics	6.3 & 7.6.4
RO1.5: Determine the economic feasibility	7.5 & 7.6.5

Surveys

Due to a lack of research regarding the human factor of mobile phone usage, surveys were conducted to obtain additional information. The first survey (APPENDIX I) gauged the acceptance of health care workers towards mobile phone usage in the work environment. Limited responses were

obtained, but it was determined that there are mixed attitudes towards the use of mobile phones in the health care environment.

A second survey (APPENDIX E) investigated the mobile phone usages of health care workers. A significant number of responses were obtained with greater detail on what health care workers use their mobile phones for.

Case study

The Pikinini project, which has been included as a case study (Section 5.4), was done as proof of the feasibility of an MHSV. Hands-on experience was gained in the development of an MHSV in the South African context.

Interviews

To confirm the current state-of-the-art and support literature research done, interviews were used. Key aspects that are current and not included directly in research studies were obtained from interviews.

Regarding the feasibility of an MHSV in South Africa, Treurnicht (APPENDIX G.2) stated that an MHSV will be feasible, if:

- The user interface / operation is user friendly (RO1.1)
- Sufficient training and change management are done with health care workers (RO1.1)
- The information system is adapted to the health care workers (RO1.3)
- It aligns with the DOH's priorities (RO1.4)
- Funding via PHC outreach teams is achieved (RO1.5)

Her response confirms that the feasibility framework covers the major aspects involved in the feasibility of an MHSV.

Business model development

In Section 8.4, business models were created to propose possible avenues by which an MHSV can be deployed in South Africa. These business models show how an MHSV can be economically viable through creating value for different stakeholders as well as creating revenue streams. The business models contribute to proving the economic feasibility of an MHSV (RO1.5).

The points made above shows that the research objectives of RO1 have been met.

9.2.2 *Business models*

The following section looks at the verification of RO2: the business models that have been developed for an MHSV in the South African context. The development of these business models is discussed in CHAPTER 8 with results given in Section 8.4. The business models were developed according to the design requirements set out in Section 1.4.2. In the following sections, it will be verified whether these design requirements have been met.

DR1: Conform to business model criteria

In a review of business models [137], the following criteria are set out as defining the essential aspects of a business model:

1. Analyses the way in which a firm does business
2. Explains business operations holistically on a systems level, both the what and the how
3. Describes business activities of a firm as well as those of outside suppliers, partners, or customers
4. Defines how value is created and captured

In Section 8.2 it is shown that Osterwalder's business canvas fulfils the above criteria for business models. The business models that were developed in Section 8.4 use Osterwalder's business canvas and thus conform to the criteria of a business model.

DR2: Show how value is created

In Section 8.3.2 the creation of value by an MHSV is discussed in broad terms. In Section 8.4.2 and 8.4.3 specific proposals are given for how value can be created for various stake holders both in the public and the private health sector.

In an interview (APPENDIX G.2), Treurnicht stated that the greatest value of an MHSV for government is the prevention of disease, which reduces the burden of disease on the country and the future burden on the health system. Fortuin (APPENDIX G.5) stated that the value of an MHSV is not only prevention of sickness but also the prevention of child mortality.

DR3: Have relevance to stakeholders

In Section 8.4 the value propositions of the business models were developed to benefit stakeholders and to be relevant for them. Goosen (APPENDIX G.3) and Fortuin (APPENDIX G.5) stated during interviews that the business models are relevant to the current industry.

According to Treurnicht (APPENDIX G.2) the relevance of an MHSV depends on the impact it will have. This impact relates to the specific area where the MHSV will be implemented (e.g. increasing

vaccination coverage from 80% to 90%) and whether the solution addresses the correct issues, i.e. those that influence vaccination coverage.

DR4: Distinguish between the private and public health sector

Separate business models were created for the public and private health sector in Section 8.4.2 and 8.4.3. Differences between the sectors were also considered and discussed.

Treurnicht (APPENDIX G.2) commented that public and private sectors require different strategies and marketing approaches. They have different motivations, with the public sector being provider-driven while the private sector is patient-driven.

DR5: Predict the effect of the NHI

An integrated business model that includes private health care participation into the public health care model was developed in Section 8.4.4. Treurnicht (APPENDIX G.2) stated that the implementation of the NHI is still unsure but that the proposed business model can be used to predict the NHI's effect, given that certain criteria are met.

The previous points show that the design requirements for the business models, and thus the research objectives of RO2, have been met.

9.2.3 *NHI*

The following section looks at the verification of RO3: to determine the effect which the NHI will have on an MHSV. The NHI is discussed in Section 6.2.3 and the business model for the NHI is given in Section 8.4.4.

In Section 6.2.3 it was found that the NHI creates an opportunity for mHealth solutions, such as an MHSV, to add value to South Africa's health care. The NHI also creates the opportunity for funding for an MHSV, if it is aligned with DOH priorities.

In Section 8.4.4 the effect of the NHI on an MHSV was shown using Osterwalder's business model canvas. The introduction of NHI as a national service will remove the competitive advantage that mobile operators could gain from a non-mandatory service, thus reducing the possible value that they can gain. However, the NHI will integrate a part of the private sector into the public sector, increasing the user base of a public MHSV to include higher-income caretakers.

One of the design requirements of the business model development (DR5) was to predict the effect of NHI. See Section 9.2.2 for more detail on how the business models consider the effect of the NHI.

The discussion above shows that the research objectives of RO3 have been met.

9.3 Validation

The aim of validation is to show that the research done is sound, convincing and well-founded. In this section the validity of the research is evaluated both internally and externally (RO5).

Internal validation evaluates whether the research process has sufficient controls to ensure that the conclusions drawn are truly warranted by the data. It is done by evaluating the research method and sources used.

External validation evaluates whether the results obtained can be used to make generalisations about the world beyond the research context (generalisability). It is done primarily though external interviews with people in the mobile phone and health industry.

Maxwell [143] gives five types of validation in qualitative methods as shown in Table 9-5. The validation types will be discussed below under the internal and external validation of the feasibility framework and business model development.

Table 9-5: Types of validation [143]

Validity	Definition
Descriptive validity	Factual accuracy; not being made up, selective or distorted
Interpretive validity	Research's ability to catch the meaning, interpretations, terms of the subjects
Theoretical validity	Extent to which the research explains phenomena
Generalisability	Extent to which research's theory can be useful in creating understanding within other specific groups, communities, situations and circumstances
Evaluative validity	Application of an evaluative framework; judgemental of what is being researched

9.3.1 *Internal validation*

Cohen *et al*. [144] defines the aim of internal validation as follows: "Internal validation seeks to demonstrate that the explanation of a particular event, issue or set of data which a piece of the research provides can actually be sustained by the data."

The question that internal validation poses is whether the research process has sufficient controls to ensure that the conclusions drawn are truly warranted by the data. It is done by evaluating the research method and sources used. The research is divided into the feasibility framework and business development, and the internal validity of each is discussed below.

Feasibility framework

The theoretical basis of the feasibility framework that is used in this study is given in APPENDIX A.1 and A.2. The sub-groups were chosen on the basis of scale (meso/macro) and the relevance to an mHealth solution in South Africa.

The components of a feasibility study for a management information system are based on work by O'Brien and Marakas [145] which has been applied to many cases on information management. The conceptual model by Van Dyk [146] was developed through extensive workshops with health care workers in South Africa.

The feasibility framework is used to determine the state of the art using literature surveys and interviews. The literature used in this study includes journal articles (white literature) and current reports (grey literature). Surveys were used to add to information that was lacking in literature.

The feasibility dashboard (Section 7.6) can be seen as an evaluative framework that has been applied to the research field. The dashboard is used to summarise the findings from the feasibility framework to give an overview of the research.

Seeing that the feasibility framework is based on relevant theory and that the framework provided a process to conduct research, it can be said that the research process has sufficient controls to warrant the results of the research.

Business model development

The theoretical background of the business model development is discussed in Section 8.1 and 8.2. Zott *et al*. [137] identifies four common themes for business models. These themes are met by the business models developed in the following way:

1. New unit of analysis: The proposed business models analyses how an MHSV will do business.
2. System-level concept: The value proposition describes what an MHSV does, while the channels, customer relationships, revenue streams, key resources and key activities describe how it is done.
3. Activity centred: The key activities of an MHSV describe the activities that are required for business operation.
4. Value focused: The value proposition is the centre of the business model.

By following the themes of Zott *et al*. [137], the proposed business models are shown to be valid.

These business models are based on Osterwalder's business canvas, which was co-authored by 470 business model canvas practitioners from 45 countries [21]. Practitioners of the model include companies such as Ericson, 3M, Deloitte, Logica, Capgemini and Telenor among others. The business canvas was also applied to the telemedicine field by Chen *et al*. [138]. It shows that Osterwalder's business canvas is a valid model theoretically and that it is applicable to mHealth.

9.3.2 *External validation*

Cohen *et al*. [144] defines the aim of external validation as follows: “External validation refers to the degree to which the results can be generalised to the wider population, case, or situations.” They hold that qualitative research needs to provide clear, detailed and in-depth descriptions of findings so that external parties can evaluate the degree to which the findings can be generalised to another situation.

External validation is done through external interviews with experts in the mobile phone and health industry. The following section describes the external validation of the feasibility framework and the business models that were developed. See APPENDIX G for detail on the interviews.

Feasibility framework

Treurnicht (APPENDIX G.2) commented that the feasibility framework covers the majority of areas for an MHSV and that it is mostly generic for mHealth services. Goosen (APPENDIX G.3) stated that the feasibility framework provided a good cross-section of the most important components of an MHSV. He further stated that the factors of the feasibility framework will apply to the broader scope of mHealth projects in South Africa and in other developing countries with similar health care systems.

Strydom (APPENDIX G.4) commented that the only thing lacking in the feasibility framework is an implementation strategy that includes continuous support for the service. He further stated that the feasibility framework can be generalised to mHealth projects in general and that the same factors are present for any mHealth project on chronic disease.

Treurnicht (APPENDIX G.2) remarked that the framework dashboard lacks the underlying details as to the reasons behind the colour indications.

Goosen (APPENDIX G.3) commented that the specific roles and demographics of groups such as “health care workers” and “management” require more definition. These roles should be refined into different sectors and levels according to the skill required to perform certain tasks for an MHSV. Studies on the proficiency of each sub-group to perform such tasks would have to be investigated.

Strydom (APPENDIX G.4) stated that he does not think that human factors are such a big problem, because it can be solved with enough funding and training. According to Strydom the biggest hindrance to an MHSV is the policies and ethics, seeing that so many people have to be involved in making the decision to approve the service. He rated information capturing as the second biggest hindrance, because not all facilities have defined systems in place. He rated cost and funding third, because funding can always be obtained from somewhere.

Regarding the generalizability of the feasibility framework, Fortuin (APPENDIX G.5) noted that general statements could be made, but that a more in-depth study is required to identify underlying principles.

Business model development

Goosen (APPENDIX G.3) stated that the business model canvas is a good starting point for technology-driven projects. He also stated that the developed business models are applicable to the current industry.

Treurnicht (APPENDIX G.2) commented that the business models can be generalised, but the targeted patients will change. Different strategies and marketing will also be used. The rest will be similar for other mHealth services.

Goosen (APPENDIX G.3) remarked that the business models can, in principle, be used as a base for other mHealth initiatives of similar nature. Goosen further commented that the specific groups involved should be elaborated upon, e.g. to use “Department of Health” instead of “Government”.

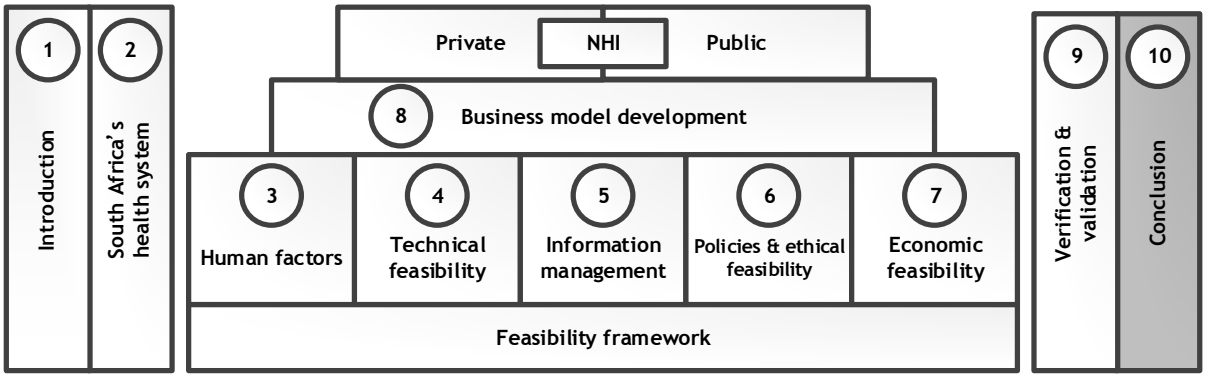
Strydom (APPENDIX G.4) commented on how Mezzanine’s revenue stream works, but he could not answer the questions regarding the business model.

Fortuin (APPENDIX G.5) stated that the business models are comprehensive.

9.4 Conclusion

In this chapter the research done in this paper was verified and validated through different methods. Verification (RO4) was done through reviewing whether the design intent for the feasibility framework and the business models was met. Validation (RO5) was done by reviewing the internal validity of the research and using interviews to show the external validity of the research.

CHAPTER 10 CONCLUSION



The purpose of this study is to determine the feasibility of an MHSV in the South African context and to develop business models for such solutions. Through achieving various research objectives, the feasibility of an MHSV was determined and business models were developed. Results were presented to individuals of relevant industries and were shown to be valid and relevant.

The outcome of this chapter is to synthesize all work done in this paper. Limitations of this study are noted and possibilities for further studies are mentioned.

10.1 Review of research questions

The purpose of the research study led to the formulation of research questions. These research questions were addressed throughout the study. The conclusion of each research question is given below, with references.

RQ1.1 – Is an MHSV feasible in terms of human factors?

Conclusion: Yes, even though there are challenges regarding the mobile phone literacy of caretakers and health care workers as well as the work environment of health care workers and management (Section 3.5).

RQ1.2 – Is an MHSV technically feasible?

Conclusion: Yes, even though the lack of computer infrastructure in the public health sector will have to be addressed (Section 4.5).

RQ1.3 – Is an MHSV feasible in terms of information management?

Conclusion: Yes, even though ensuring data quality will be a challenge. The integration of an MHSV into the existing information systems should also be addressed (Section 5.5).

RQ1.4 – Is an MHSV feasible in terms of policies and ethics?

Conclusion: Yes, even though there are no clear ethics guidelines or policies for mHealth solutions which will lead to a delayed approval process. The approval from all relevant bodies will have to be managed well (Section 6.3).

RQ1.5 – Is an MHSV economically feasible?

Conclusion: Yes, even though creating an economically feasible business solution requires establishing multiple partnerships to be successful (Section 7.5).

RQ1 – Is an MHSV feasible in South Africa?

Conclusion: Yes, even though challenges have been identified in certain areas of feasibility, an MHSV is feasible in South Africa if properly managed (Section 7.6).

RQ2 – How should a business model for an MHSV in South Africa be structured?

Conclusion: Section 8.4 shows how business models for an MHSV can be structured. Interviews (APPENDIX G) reveal additional factors that have to be taken into consideration.

RQ3 – What is the effect of the NHI on an MHSV?

Conclusion: The NHI may create an opportunity for an MHSV to be implemented through South Africa and provide the prospect of funding (Section 6.2.3). Section 8.4.3 shows how the NHI is predicted to integrate the business case for an MHSV between the public and private sector.

RQ4 – Are these research objectives met?

Conclusion: Yes, the various research objectives and design requirements have been met (Section 9.2).

RQ5 – Is the research well-founded?

Conclusion: Yes, the research possesses sufficient internal control to warrant the results obtained, and the results are generalisable to other situations (Section 9.3).

10.2 Mobile health solution for vaccination feasibility

A feasibility dashboard that summarises the findings of the feasibility framework is presented in Section 7.6. The major challenges identified for an MHSV were change management in the health care sector, governmental policies regarding mHealth solutions and setting up an economically feasible business case. Even though there are challenges, an MHSV is still feasible in the South African context.

10.3 Business models

The business models that were developed in Section 8.4 show different ways in which value can be created to make an MHSV economically feasible. From interviews it was found that the business models incorporate most aspects needed for an MHSV's business case. Given that the assumptions hold, the suggested MHSV is a feasible business venture.

10.4 Limitations

Due to the methodology used, the study inherently has certain limitations.

The feasibility study was not done as a structured review of each area of feasibility. The result is that some research papers in these fields were excluded from this study. Many grey sources were also included in the study due to a lack of relevant academic research papers.

The details of the NHI are still unclear, which makes its impact on the health system difficult to predict. The effect of the NHI on business models proposed in this study will only hold if the assumptions regarding the NHI hold true in the future.

The scaling system that was developed for the feasibility dashboard does not follow an objective scaling system. It is a subjective indication of how feasible each area is, even though it is backed by objective sources.

10.5 Future research

Through the course of this study, knowledge gaps were identified that could be addressed by further research.

The integration of an mHealth solution into the existing health information system is complex. Research on such integration will be beneficial to future mHealth solutions, as well as any future solutions which aim to integrate into the health information systems.

There are companies that facilitate change management in the public health sector for a variety of solutions and services. Research on how to approach change management in the public health sector can be beneficial to all future solutions and services.

The root causes for low or high immunisation coverage in certain areas of South Africa is unknown. Social factors that influence patients' visits to clinics for vaccination or other services have also not been studied. Such research can provide valuable insight on which factors influence immunisation the most, which in turn can be used to address such factors.

10.6 Final thoughts

This study originated with a fascination of using mobile phones in the field of health care. Mobile phone technology has experienced much development in a short amount of time, and it continues to be a dynamic environment.

Mobile phones bridge the gap between health care and the individual, placing technology at the fingertips of the individual. The increase in mobile phone ownership in developing countries has created a platform for improved health care delivery.

A paper in the *Lancet* [35] revealed that South Africa is lagging behind in reaching the Millennium Development Goals (MDG's). Research in the field of Malaria, HIV, TB and other deceases (MDG 6) has received more attention than research in reducing the mortality of children under the age of five years (MDG 4). This study was done in the hope of providing more research to reduce child mortality.

Unfortunately, South Africa's health system is complex, and there is no 'silver bullet' that can solve the problems that the health system faces. Any solution has to address many issues at once and on a variety of levels. It leads to a complex process when implementing solutions in the health system, as shown in this study.

In the face of a strained public health system, this research hopes to create a stepping stone towards improved health care for children.

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APPENDIX A FEASIBILITY FRAMEWORK

Many factors and criteria need to be considered when doing feasibility studies, most of them originating from common sense and intuition [147]. A feasibility study is used to gather a wide range of data in order to enable management to decide whether to proceed with the system study [148].

According to a report on health information systems in developing countries [139], the effectiveness of an immunisation campaign depends on its information systems due to dependence on prior health system activities (e.g. what vaccinations were performed). Because the vaccination process is information dependent, the feasibility of information management systems needs to be considered. In many instances, part of the life cycle of system development is to conduct a feasibility study [147].

A.1 Components of feasibility

In the development of information systems, the major components of a feasibility study are [148]:

- Technical feasibility
- Economic feasibility
- Operational feasibility

According to O'Brien and Marakas [145], the components of a feasibility study for a management information system are:

- Operational feasibility
- Economic feasibility
- Technical feasibility
- Human factors feasibility
- Legal / political feasibility

All the aforementioned components are specific to the feasibility of an information system. Part of an MHSV includes an information system. To determine the feasibility of an MHSV as a whole, these components of information systems are used, but factors regarding the wider health care context also need to be considered. In the following section these factors are discussed.

A.2 Feasibility for health

One framework that incorporates factors related to telemedicine services is a conceptual model developed by Van Dyk [146]. This model expands the five M's (Man, Machine, Material, Method, Money) [149] across different levels of a telemedicine service as set out in Table A-1.

Table A-1: Conceptual model for telemedicine service maturity model (TMSMM) [146]

	Capture, Diagnose/ Analyse, React processes	Data Transmission processes	Meso-level processes	Macro-level processes
Man	patient or health care worker	patient or health care worker	health care worker community	the society
Machine	telemedicine device, mobile phone, etc.	internet service, mobile phone network, etc.	physical infrastructure	national technology infrastructure
Material	data, images, video, etc.	data, images, video, etc.	electronic medical record (EMR)	electronic health record (EHR)
Method	work procedure	network service	change management process	national and provincial policies and strategies
Money	operational costs	cost of transmission service	institutional business model	national business case

The five M's can be linked to the major feasibility components for information systems as follows:

- Man – Human factor feasibility
- Machine – Technical feasibility
- Material – Operational feasibility
- Method – Legal / political feasibility (policy)
- Money – Economic feasibility

A.3 Feasibility framework

The five major factors of feasibility in combination with the different levels of telemedicine service form a framework that will be used for the feasibility study in the following manner:

Table A-2: Feasibility framework for MHSV (Same as Table 7-10)

Feasibility	Micro level	Meso-level	Macro-level
Human factors	Caretakers	Health care workers	Management
Technical	Mobile phones & software	Mobile network infrastructure	Health information system infrastructure
Information management	Information capturing	Information integration	Information system
Policies and ethics	Ethical aspects	Regulation of information and apps	National strategies
Economic	Costs & funding	National business case	Health financing

The feasibility framework is used to represent the feasibility of an MHSV in South Africa, as shown in the feasibility dashboard in Section 7.6.

APPENDIX B CLOUD SERVICE COSTS

The following section gives compares the cost of ownership to cloud services, and gives examples of costs for cloud based services. Two popular cloud services are given for example purposes; further costing information is available online. Cost calculations used the exchange rate of R 9,326 per USD (as per Windows Azure website on 30 October 2013).

B.1 TCO example

On the AWS [150] website, there is a TCO (Total cost of ownership) calculator [151] to show how using cloud services are less expensive that owning and maintaining the services. In Table B-1 the difference in cost between ownership and AWS cloud services are given. In Figure B-1 a chart is given to visually depict the difference. These figures show that cloud services would be ideal for a start-up project such as an MHSV – with cloud services providing necessary services, without a large capital investment, with the added benefit of being scalable.

Table B-1: Example of cost of ownership vs AWS cloud services [151]

	On-Premises	AWS	Difference
Servers	R 247 876	R 136 952	R 110 923
Storage	R 446 893	R 78 954	R 367 948
Network	R 369 002	R 17 440	R 351 562
Environment	R 1 158 289	R -	R 1 158 289
Administration	R 566 275	R 141 569	R 424 706
Total/year	R 2 788 334	R 374 905	R 2 413 429

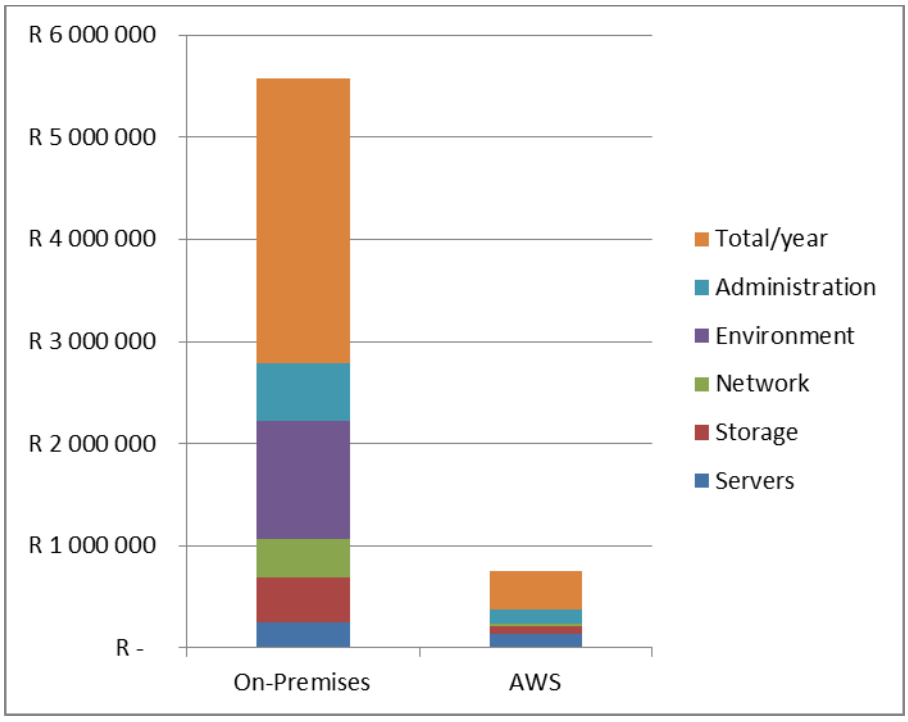


Figure B-1: Chart comparing cost of ownership and AWS cloud services [151]

B.2 Windows Azure Mobile Services

This section gives costing for a "pay-as-you-go" plan (as opposed to a reserved usage plan). Costs for the Windows Azure Mobile Services are given below (Table B-2), followed by outbound data transfer prices in Table B-3 (inbound data transfers are free) and then data storage prices (Table B-4).

Table B-2: Costs for the Windows Azure Mobile Services [152]

	FREE	STANDARD	PREMIUM
Price	Free	R 234 / month	R 1 856 / month
	(up to 10 services / month)	per unit	per unit
API Calls	500K	1.5M per unit	15M per unit
Active Devices	500	Unlimited	Unlimited
Scale	N/A	Up to 6 units	Up to 10 units
Scheduled jobs	Limited	Included	Included
SQL Database	20 MB included,	20 MB included,	20 MB included,
(required)	Standard rates apply for additional capacity	Standard rates apply for additional capacity	Standard rates apply for additional capacity

Table B-3: Data transfer prices for the Windows Azure [152]

Outbound data transfers	Cost
First 5 GB / Month 1	Free
5 GB - 10 TB 2 / Month	R 1,772 per GB
Next 40 TB / Month	R 1,399 per GB
Next 100 TB / Month	R 1,212 per GB
Next 350 TB / Month	R 1,119 per GB

Table B-4: Database prices for the Windows Azure [152]

DATABASE SIZE	PRICE PER DATABASE PER MONTH (PRORATED DAILY)	
0 to 100 MB	R 46,59	
100 MB to 1 GB	R 93,17	
1 GB to 10 GB	R 93,17	R 37,27
	for the first GB	for each additional GB
10 GB to 50 GB	R 428,55	R 18,62
	for the first 10 GB	for each additional GB
50 GB to 150 GB	R 1 173,84	R 9,316
	for the first 50 GB	for each additional GB

B.3 Mobile applications on AWS

Amazon Web Services (AWS) also offer a variety of services for mobile app development such as Push notification, Geolocation, and data and file storage [150]. For a MHSV, the Amazon DynamoDB is the most suited database. Costs related to the database is given in Table B-5, Table B-6 and Table B-7, while additional costs related file storage is given in Table B-8 and Table B-9. Data storage costs are based on AWS' Simple Storage Service (S3).

Table B-5: Cost of throughput capacity for AWS [150]

Provisioned Throughput Capacity
Write Throughput: R 0,069 per hour for every 10 units of Write Capacity
(enough capacity to do up to 36 000 writes per hour)
Read Throughput: R 0,069 per hour for every 50 units of Read Capacity
(enough capacity to do up to 180 000 strongly consistent reads, or 360 000 eventually consistent reads, per hour)

Table B-6: Cost of indexed data storage for AWS [150]

Indexed Data Storage
First 100 MB stored per month is free.
R 2,658 per GB-month thereafter

Table B-7: Data transfer cost for AWS [150]

Data Transfer IN To Amazon S3		
All data transfer in	free	
Data Transfer OUT From Amazon S3 To:		
Amazon EC2 in the same region	free	
Another AWS Region or Amazon CloudFront	R 0,839	per GB
Data Transfer OUT From Amazon S3 To Internet		
First 1 GB / month	free	per GB
Up to 10 TB / month	R 1,772	per GB
Next 40 TB / month	R 1,399	per GB
Next 100 TB / month	R 1,212	per GB
Next 350 TB / month	R 1,119	per GB

Table B-8: Standard file storage costs for AWS' S3 [150]

Standard Storage		
First 1 TB / month	R 0,886	per GB
Next 49 TB / month	R 0,746	per GB
Next 450 TB / month	R 0,653	per GB
Next 500 TB / month	R 0,606	per GB
Next 4000 TB / month	R 0,560	per GB
Over 5000 TB / month	R 0,513	per GB

Table B-9: Cost of requests for AWS's S3 [150]

Request Pricing	
PUT, COPY, POST, or LIST Requests	R 0,047 per 1 000 requests
GET and all other Requests	R 0,037 per 10 000 requests
Delete Requests	Free

APPENDIX C SWOT ANALYSIS

To provide an overview of the context of an MHSV in the South Africa, a swot analysis was performed. Table C-1 show the major strengths, weaknesses, opportunities and threats (SWOT) for an MHSV.

Table C-1: SWOT analysis of an MHSV in South Africa

	Helpful	Harmful
Internal origin	*Strengths*: • Improved information management • Performance monitoring	*Weaknesses*: • Creation of an additional system • Training required
External origin	Opportunities: • Facilitate communication between clinic and caretaker • Possible single input system for multiple services • Alignment with DOH priorities • Application in PHC outreach teams and integration of services	*Threats*: • Literacy (caretakers & health workers) • Mobile phone work culture • Conflicting DOH priorities • Resistance from PHC outreach teams and integration of services

From Table C-1 it can be seen that the DOH priorities, PHC outreach teams and integration of services offer both an opportunity and a threat to an MHSV. If the threats in the analysis can be sufficiently addressed, then the opportunities can be utilised.

APPENDIX D IMMUNISATION SCHEDULE

The following is a table showing the national standard of immunisations to be given for children. As the need arise, districts and health workers may give additional immunisations.

Table D-1: Public expanded programme on immunisation schedule [4].

Age of child	Vaccines needed
At birth	BCG Bacilles Calmette Guerin
	OPV (0) Oral Polio vaccine
6 weeks	OPV (1) Oral Polio vaccine
	RV (1) Rotavirus vaccine
	DTaP-IPV/Hib (1) Diphtheria, Tetanus, acellular Pertussis, Inactivated Polio vaccine and Haemophilus influenzae type b combined
	Hep B (1) Hepatitis B vaccine
	PCV7 (1) Pneumococcal Conjugated vaccine
10 weeks	DTaP-IPV/Hib (2) Diphtheria, Tetanus, acellular Pertussis, Inactivated Polio vaccine and Haemophilus influenzae type b combined
	Hep B (2) Hepatitis B vaccine
14 weeks	RV (2) Rotavirus vaccine
	DTaP-IPV/Hib (3) Diphtheria, Tetanus, acellular Pertussis, Inactivated Polio vaccine and Haemophilus influenzae type b combined
	Hep B (3) Hepatitis B vaccine
	PCV7 (2) Pneumococcal Conjugated vaccine
9 months	Measles vaccine (1)
	PCV7 (3) Pneumococcal Conjugated vaccine
18 months	DTaP-IPV/Hib (4) Diphtheria, Tetanus, acellular Pertussis, Inactivated Polio vaccine and Haemophilus influenzae type b combined
	Measles Vaccine (2)
6 years	Td vaccine Tetanus and reduced strength of diphtheria vaccine
12 years	Td vaccine Tetanus and reduced strength of diphtheria vaccine

The following table gives the vaccination options available in the private health care.

Table D-2: Private practice vaccination schedule options (130)

Age of child	Private practice: Option 1	Private practice: Option 2	Age of child	Private practice: Option 3
At birth	OPV (0) BCG	OPV (0) BCG HBV1	At birth	OPV (0) BCG
6 weeks	RV (1) DTaP-IPV//Hib (1) HBV (1) PCV (1)	RV (1) DTaP-IPV//Hib/HBV (1) PCV (1)	2 months	RV (1) DTaP-IPV//Hib/HBV (1) PCV (1)
10 weeks	DTaP-IPV//Hib (2) HBV (2) PCV (2)	DTaP-IPV//Hib/HBV (2) PCV (2)	3 or 4 months	RV (2)2 DTaP-IPV//Hib (2) PCV (2)
14 weeks	DTaP-IPV//Hib (3) HBV (3) PCV (3) RV (2)2	DTaP-IPV//Hib/HBV (3) PCV (3) RV (2)2	4 or 6 months	DTaP-IPV//Hib/HBV (3) PCV (3)
9 months	Measles vaccine Chickenpox (varicella) vaccine (1)3	Measles vaccine Chickenpox (varicella) vaccine (1)3	9 months	Measles vaccine Chickenpox (varicella) vaccine (1)3
12-15 months	MMR (1) Hepatitis A vaccine (repeat 6 months later) PCV (4)	MMR (1) Hepatitis A vaccine (repeat 6 months later) PCV (4)	12-15 months	MMR (1) Hepatitis A vaccine (repeat 6 months later) PCV (4)
18 months	DTaP-IPV//Hib (4)	DTaP-IPV//Hib or DTaP- IPV//Hib/HBV (4)4	18 months	DTaP-IPV//Hib or DTaP-IPV//Hib/HBV(4)4
5-6 years	DTaP or TdaP-IPV MMR (2) Chickenpox (varicella) vaccine(2)	DTaP or TdaP-IPV (at 6 years) MMR(2) Chickenpox (varicella) vaccine(2)	5-6 years	DTaP or TdaP vaccine (at 6 years) MMR(2) Chickenpox (varicella) vaccine(2)
9 or 10 years	HPV (quadrivalent from 9 years)5 HPV (bivalent from 10 years)6	HPV (quadrivalent from 9 years)5 HPV (bivalent from 10 years)6	9 or 10 years	HPV (quadrivalent from 9 years)5 HPV (bivalent from 10 years)6
12 years	TdaP-IPV	TdaP-IPV	12 years	TdaP-IPV

The following table gives the trade names for vaccinations, and the age group for which they are appropriate.

Table D-3: Vaccines trade names and relevant age groups (130)

Vaccine	Trade name	Age group
OPV	OPV-Merieux® Polioral®	Birth to adulthood; not generally recommended in adulthood due to vaccine- associated paralytic polio (VAPP)
BCG	BCG Vaccine®	Usually at birth only; in certain cases, up to 1 year
RV	Rotarix®	First dose before 14 weeks, second before 24 weeks
DTaP-IPV/Hib	Pentaxim®	6 weeks to 2 years
TdaP-IPV	Adacel Quadra®	6 years to adulthood
HBV	Heberbiovac HB® Engerix-B®	Birth to adulthood; dose according to age
PCV	Prevenar® Synflorix®	6 weeks to 9 years 6 weeks to 2 years
DTaP-IPV//Hib/HBV	Infanrix® Hexa	8 weeks to 2 years
MMR	Trimovax® Priorix®	1 year to adulthood
HPV	Gardasil® (quadrivalent) Cervarix® (bivalent)	9-26 years 10 years and older
Td vaccine	Diftavax®	6 years and older
Measles vaccine	Rouvax®	9 months and older
Chickenpox vaccine	Varilrix®	9 months and older
Hepatitis A	Avaxim 80® Havrix Junior®	1–15 years

APPENDIX E MOBILE PHONE USAGE SURVEY

E.1 Methodology

This survey was developed and distributed in collaboration with Andre Hartmann. Ethical clearance to distribute the survey was obtained from Stellenbosch University's Health Research Ethics Committee (Ref. S12/11/277) under the study "An investigation on the factors that influence the success rate of telemedicine services in the public health sector of South Africa".

The survey was sent to different kinds of health workers in the public sector to assess their mobile phone usage within the health sector. The 32 respondents included specialists (10), medical officers (8), medical students (8), community service doctors (3), managerial staff (2) and a medical intern (1).

E.2 Results

Summary of results

- 94% use their mobile device for health care purposes
- 91% access health information via the Internet
- 72% use their mobile device to capture, document or transmit medical data
- 75% use medical applications on their mobile phones
- 53% said financial benefit would motivate them to use mobile phones
- Only two respondents received any form of reimbursement for the use of their mobile device

Further analysis of the results can be found in Hartmann's thesis [20]. Section D.3 shows the questionnaire and section D.4 gives the responses.

E.3 Questionnaire

Use of Mobile Devices in Health Care

At the moment their is lack of research data regarding the use of mobile devices in the health care sector. The data collected by this survey will provide useful information regarding the use of mobile phones for health purposes in the public health care sector of the Western Cape.
Mobile devices such as cellphones or tablets are used within the health care community to access, communicate and/or transmit medical information. Examples range from calling a medical specialist for a second opinion, to capturing and transmitting medical information between mobile devices.

The survey consists of 4 pages and will take less than 6 min.

* Required

Demographics

What is the job title for your current position? *
Tick the option which closest represents your job title.

- ◯ Medical Officer
- ◯ Medical Specialist
- ◯ Medical Student
- ◯ Nures
- ◯ Administrative Staff
- ◯ Managerial Staff
- ◯ Intern
- ◯ Community Service Doctor
- ◯ Option 9

What is your gender? *

- ◯ Female
- ◯ Male

what is your age? *

- ◯ 18 to 24
- ◯ 25 to 34
- ◯ 35 to 44
- ◯ 45 to 54
- ◯ 55 to 64
- ◯ 65 to 74
- ◯ 75 to older

What is the highest level of education you have completed? *

- ◯ Matric
- ◯ Diploma
- ◯ Degree
- ◯ Masters
- ◯ Doctorate
- ◯ Other:

Number of years (health care sector) work experience? *

What is the name of the Health Care Facility you are currently working at? *

What type of Health Care Facility do you work at? *

- ◯ Primary (District Hospital and/or CHC/Clinic)
- ◯ Secondary (Regional Hospital)
- ◯ Tertiary
- ◯ Other:

Questionnaire continued (2)

Which type of mobile device are you currently using? *
More than one option available.

- ☐ Basic mobile phone (voice & SMS only)
- ☐ Feature mobile phone (internet & camera capabilities)
- ☐ Smart phone (internet, camera & application capabilities)
- ☐ Tablet (internet, camera & application capabilities)
- ☐ Laptop

Which operating system does your mobile device use? *

- ○ Blackberry (Blackberry OS)
- ○ Nokia (Simbia or Windows Mobile OS)
- ○ iPhone (iOS)
- ○ Samsung, HTC (Android OS)
- ○ Other:

Which mobile service provider do you subscribe to? *

- ○ MTN
- ○ Vodacom
- ○ CellC
- ○ 8ta
- ○ Virgin Mobile
- ○ Other:

How would you rate your mobile device signal coverage? *

1 2 3 4 5

(No signal most of the time) ○ ○ ○ ○ ○ (Good signal, Always available)

Do you use your mobile device for health care purposes at work? *

- ○ Yes (personal mobile device)
- ○ Yes (company issue mobile device)
- ○ No

Did you purchase your mobile device with the intention of using it in the health care sector? *

- ○ Yes
- ○ No
- ○ It never came to mind to use my mobile device for such a purpose, when I purchased it.

Do you use your mobile device to assist you in your work, by attaining information via the internet?

- ○ Yes
- ○ No

Do you use any medical applications on your mobile device? *
If YES, please specify the medical application which you use.

- ○ No
- ○ Yes

If YES, please specify the medical application which you use.

Have you purchased any kind of medical application for your mobile device? *
More than one option can be selected.

- ☐ Yes, but it was only freeware
- ☐ Yes, and I paid for it
- ☐ Yes, and I convinced (some of) my colleague(s) to do the same
- ☐ Yes, but I am not using it for work purposes
- ☐ Yes, and I am using it for work purposes
- ☐ No, but I would not mind doing so
- ☐ No, I do not know how to
- ☐ No, I will never download medical apps to my mobile device
- ☐ Other:

If YES, please specify the price of the application.

Do you use your mobile device to capture, document or transmit medical data? *

- ○ Yes
- ○ No

Questionnaire continued (3)

Which of the following factors would motivate you to use mobile devices for Health Care purposes? *

More than one option can be selected.

- ☐ If I get financial reimbursement for using it
- ☐ Better quality mobile devices
- ☐ If I get performance incentives for using it
- ☐ If I have a specifically designed mobile app
- ☐ If I get trained to use it
- ☐ I am curious about new technology
- ☐ It makes my job easier
- ☐ It contributes to better health care for patients
- ☐ All of my colleagues use it
- ☐ If x-ray images and lab results are accessible via the internet

Does the Health Care Facility you work at have a mobile device policy? *

- ○ Yes
- ○ I do not know
- ○ No

If YES, please describe in short the Health Care Facility's policy on mobile devices

E.4 Responses

Respondent	Timestamp	What is the job title for your current position?	Do you use your mobile device for health care purposes at work?	Do you use your mobile device to assist you in your work, by attaining information via the internet?	Do you use any medical applications on your mobile device?	Do you use your mobile device to capture, document or transmit medical data?	How do you capture or document medical data with your mobile device?	Do you consider transmitting/receiving medical information/data via mobile device....	Medical information/data captured using the mobile device camera is....	Does the Health Care Facility you work at have a mobile device policy?
1	41436,68457	Community Service Doctor	Yes (personal mobile device)	Yes	Yes	Yes	Digital camera, Text (SMS based)	Highly secure	4	No
2	41437,63083	Community Service Doctor	Yes (personal mobile device)	Yes	Yes	Yes	Digital camera	Fairly secure	4	No
3	41441,39142	Community Service Doctor	Yes (personal mobile device)	Yes	Yes	Yes	Digital camera, Text (SMS based)	Fairly secure	4	Yes
4	41451,96549	Intern	Yes (personal mobile device)	Yes	Yes	Yes	Digital camera	Fairly secure	4	No
5	41435,42816	Managerial Staff	Yes (personal mobile device)	Yes	Yes	Yes	Digital camera, Voice recording	Fairly secure	4	I do not know
6	41436,84736	Managerial Staff	Yes (personal mobile device)	Yes	No	Yes	Digital camera, Text (SMS based)	Fairly secure	5	I do not know
7	41435,97906	Medical Officer	Yes (personal mobile device)	Yes	Yes	Yes	Digital camera	Fairly secure	4	No
8	41437,68745	Medical Officer	Yes (personal mobile device)	Yes	Yes	Yes	Digital camera, Text (SMS based)	Fairly secure	3	No
9	41438,30866	Medical Officer	Yes (personal mobile device)	Yes	Yes	Yes	Digital camera	Fairly secure	5	No
10	41444,86669	Medical Officer	Yes (personal mobile device)	Yes	Yes	Yes	Digital camera, Text (SMS based)	Fairly secure	5	I do not know
11	41444,94472	Medical Officer	Yes (personal mobile device)	Yes	Yes	No				I do not know
12	41451,75885	Medical Officer	Yes (personal mobile device)	Yes	Yes	Yes	Digital camera, Text (SMS based)	Fairly secure	4	I do not know
13	41451,81477	Medical Officer	Yes (personal mobile device)	Yes	Yes	Yes	Digital camera	Fairly secure	4	No
14	41452,86047	Medical Officer	Yes (personal mobile device)	No	No	No				I do not know
15	41435,81686	Medical Specialist	issue mobile device)	Yes	No	Yes	Digital camera, Text (SMS based)	Fairly secure	3	No
16	41436,37161	Medical Specialist	Yes (personal mobile device)	Yes	Yes	Yes	Digital camera	Highly secure	5	Yes
17	41436,64124	Medical Specialist	Yes (personal mobile device)	Yes	Yes	Yes	Digital camera, Text (SMS based)	Fairly secure	4	No
18	41437,57425	Medical Specialist	Yes (personal mobile device)	Yes	Yes	Yes	Digital camera, Text (SMS based)	Fairly secure	4	No
19	41437,927	Medical Specialist	Yes (personal mobile device)	Yes	Yes	Yes	Digital camera, Text (SMS based)	Fairly secure	4	I do not know
20	41443,57635	Medical Specialist	No	No	No	No				I do not know
21	41444,91078	Medical Specialist	Yes (personal mobile device)	Yes	Yes	Yes	Text (SMS based), Whatsapp	Questionable	3	I do not know
22	41450,80568	Medical Specialist	Yes (personal mobile device)	Yes	Yes	Yes	Digital camera	Highly secure	4	No
23	41451,43434	Medical Specialist	Yes (personal mobile device)	Yes	Yes	Yes	Digital camera, Text (SMS based)	Unsecure	4	No
24	41456,63286	Medical Specialist	Yes (personal mobile device)	Yes	No	No				No
25	41435,70074	Medical Student	Yes (personal mobile device)	Yes	No	Yes	Digital camera, Text (SMS based)	Questionable	2	No
26	41435,78693	Medical Student	No	No	Yes	No				I do not know
27	41435,81699	Medical Student	Yes (personal mobile device)	Yes	No	No				I do not know
28	41435,90396	Medical Student	Yes (personal mobile device)	Yes	Yes	No				I do not know
29	41435,94495	Medical Student	Yes (personal mobile device)	Yes	Yes	Yes	Digital camera	Questionable	4	I do not know
30	41436,4349	Medical Student	Yes (personal mobile device)	Yes	No	Yes	Digital camera	Fairly secure	3	No
31	41436,51663	Medical Student	Yes (personal mobile device)	Yes	Yes	No				I do not know
32	41437,8111	Medical Student	Yes (personal mobile device)	Yes	Yes	No				I do not know

Responses continued (2)

Respondent	Did you purchase your mobile device with the intention of using it in the health care sector?	Do you receive any reimbursement for the use of mobile devices to you in your work?	Which medical mobile applications do you use?	Please specify how much you paid for the medical application you purchased	How do you transmit/receive medical information/data via your mobile device?	What type of Health Care Facility do you work at?	Have you purchased any kind of medical application for your mobile device?	Which of the following factors would motivate you to use mobile devices for Health Care purposes?
1	Yes	No	Med calc, Medscape, ICD10,	1,99	IM (Instant Messaging Service i.e. Whatsap or MixIt), E-mail	Primary (District Hospital and/or CHC/Clinic)	Yes, but it was only freeware, Yes, and I paid for it , Yes, and I am using it for work purposes	I am curious about new technology, It makes my job easier, It contributes to better health care for patients, All of my colleagues use it, If x-ray images and lab results are accessible via the internet
2	No	No	Medcalc,traumapaedia,drug doses	80	IM (Instant Messaging Service i.e. Whatsap or MixIt), E-mail	Primary (District Hospital and/or CHC/Clinic)	Yes, and I paid for it	If I get financial reimbursement for using it, It makes my job easier, If x-ray images and lab results are accessible via the internet
3	It never came to mind to use my mobile device for such a purpose, when I purchased it.	No	Traumapaedia	Unkown	MMS (Multimedia Messaging Service), IM (Instant Messaging Service i.e. Whatsap or MixIt), E-mail	Primary (District Hospital and/or CHC/Clinic)	Yes, and I paid for it , Yes, and I convinced (some of) my colleague(s) to do the same	If I get financial reimbursement for using it, Better quality mobile devices, It makes my job easier, It contributes to better health care for patients, All of my colleagues use it, If x-ray images and lab results are accessible via the internet
4	No	No	MedScape		SMS, MMS (Multimedia Messaging Service), IM (Instant Messaging Service i.e. Whatsap or MixIt), E-mail	Secondary (Regional Hospital)	No, but I would not mind doing so	If I have a specifically designed mobile app, If I get trained to use it, I am curious about new technology, It makes my job easier, It contributes to better health care for patients, All of my colleagues use it, If x-ray images and lab results are accessible via the internet
5	No	No	instant ECG		SMS, MMS (Multimedia Messaging Service), IM (Instant Messaging Service i.e. Whatsap or MixIt), E-mail, WiFi	Primary (District Hospital and/or CHC/Clinic)	Yes, but it was only freeware, Yes, but I am not using it for work purposes	If I get financial reimbursement for using it, Better quality mobile devices, If I have a specifically designed mobile app, I am curious about new technology, It makes my job easier, It contributes to better health care for patients, All of my colleagues use it, If x-ray images and lab results are accessible via the internet
6	Yes	No			SMS, E-mail	Primary (District Hospital and/or CHC/Clinic)	No, but I would not mind doing so	If I get performance incentives for using it, I am curious about new technology, It makes my job easier
7	It never came to mind to use my mobile device for such a purpose, when I purchased it.	No	Medscape		IM (Instant Messaging Service i.e. Whatsap or MixIt), E-mail	Primary (District Hospital and/or CHC/Clinic)	Yes, but it was only freeware, Yes, and I convinced (some of) my colleague(s) to do the same	If I get financial reimbursement for using it, It makes my job easier, It contributes to better health care for patients, If x-ray images and lab results are accessible via the internet
8	No	No	QxCalculate		IM (Instant Messaging Service i.e. Whatsap or MixIt)	Primary (District Hospital and/or CHC/Clinic)	No, but I would not mind doing so	If I get financial reimbursement for using it, Better quality mobile devices
9	No	No	Medscape app and Grays app	R40	E-mail	Primary (District Hospital and/or CHC/Clinic)	Yes, and I paid for it , Yes, and I am using it for work purposes	If I get financial reimbursement for using it, If I have a specifically designed mobile app, It makes my job easier, If x-ray images and lab results are accessible via the internet
10	No	No	medscape, qx calculate, docstogo	I can't remember	SMS, MMS (Multimedia Messaging Service), IM (Instant Messaging Service i.e. Whatsap or MixIt), E-mail	Secondary (Regional Hospital)	Yes, but it was only freeware, Yes, and I paid for it , Yes, but I am not using it for work purposes, Yes, and I am using it for work purposes	If I have a specifically designed mobile app, It makes my job easier, It contributes to better health care for patients, If x-ray images and lab results are accessible via the internet
11	It never came to mind to use my mobile device for such a purpose, when I purchased it.		Medscape	R100		Secondary (Regional Hospital)	Yes, and I paid for it , Yes, and I am using it for work purposes	If I get financial reimbursement for using it, If I have a specifically designed mobile app, If I get trained to use it, It makes my job easier, It contributes to better health care for patients, If x-ray images and lab results are accessible via the internet
12	No	No	Calculate by QxMD	Free	SMS, MMS (Multimedia Messaging Service), IM (Instant Messaging Service i.e. Whatsap or MixIt)	Primary (District Hospital and/or CHC/Clinic)	Yes, but it was only freeware	Better quality mobile devices, It makes my job easier, It contributes to better health care for patients, If x-ray images and lab results are accessible via the internet
13	Yes	No	Medscape		E-mail	Primary (District Hospital and/or CHC/Clinic)	No, but I would not mind doing so	If I have a specifically designed mobile app, If I get trained to use it, It makes my job easier
14	No					Primary (District Hospital and/or CHC/Clinic)	No, I will never download medical apps to my mobile device	It makes my job easier
15	Yes	Yes, and it covers most of my mobile device expenses	Epocrates, Medcalc, Medscape	Cannot remember was was cheap	SMS, E-mail	Secondary (Regional Hospital)	Yes, and I paid for it , Yes, and I convinced (some of) my colleague(s) to do the same, Yes, and I am using it for work purposes	If I get financial reimbursement for using it, If I have a specifically designed mobile app, It makes my job easier, It contributes to better health care for patients, If x-ray images and lab results are accessible via the internet
16	Yes	No	medscape, pregnancy wheel, google		SMS, E-mail	Secondary (Regional Hospital)	Yes, but it was only freeware, Yes, and I paid for it , Yes, and I am using it for work purposes	If I have a specifically designed mobile app, I am curious about new technology, It makes my job easier, It contributes to better health care for patients, If x-ray images and lab results are accessible via the internet
17	Yes	No	Epocrates		MMS (Multimedia Messaging Service)	Secondary (Regional Hospital)	Yes, but it was only freeware	I am curious about new technology, It makes my job easier, It contributes to better health care for patients
18	Yes	No	Wheel RE, BMICalc, Traumapedia	1 to 10 $	SMS, MMS (Multimedia Messaging Service), E-mail	Primary (District Hospital and/or CHC/Clinic)	Yes, and I paid for it , Yes, and I convinced (some of) my colleague(s) to do the same, Yes, and I am using it for work purposes	If I get financial reimbursement for using it, Better quality mobile devices, If I have a specifically designed mobile app, It makes my job easier, It contributes to better health care for patients, If x-ray images and lab results are accessible via the internet
19	No	Yes, but it barley covers my mobile device expenses	Medscape		SMS, MMS (Multimedia Messaging Service), IM (Instant Messaging Service i.e. Whatsap or MixIt), E-mail, WiFi	Primary (District Hospital and/or CHC/Clinic)	Yes, but it was only freeware, Yes, and I convinced (some of) my colleague(s) to do the same	If I get financial reimbursement for using it, If I have a specifically designed mobile app, I am curious about new technology, It makes my job easier, It contributes to better health care for patients, If x-ray images and lab results are accessible via the internet
20	No					Secondary (Regional Hospital)	No, but I would not mind doing so	If I get financial reimbursement for using it, If I have a specifically designed mobile app, If I get trained to use it, It makes my job easier
21	Yes	No	Medscape		SMS, MMS (Multimedia Messaging Service), IM (Instant Messaging Service i.e. Whatsap or MixIt), E-mail	Secondary (Regional Hospital)	Yes, but it was only freeware	If I get financial reimbursement for using it, Better quality mobile devices, If I get performance incentives for using it, If I have a specifically designed mobile app, If I get trained to use it, I am curious about new technology, It makes my job easier, It contributes to better health care for patients, All of my colleagues use it, If x-ray images and lab results are accessible via the internet
22	Yes	No	DrugDoses, Medscape, ICD 10 HD, UpToDate	R150	SMS, MMS (Multimedia Messaging Service), IM (Instant Messaging Service i.e. Whatsap or MixIt), E-mail, WiFi	Secondary (Regional Hospital)	Yes, and I convinced (some of) my colleague(s) to do the same, Yes, and I am using it for work purposes	If I get financial reimbursement for using it, If I have a specifically designed mobile app, I am curious about new technology, It makes my job easier, It contributes to better health care for patients, If x-ray images and lab results are accessible via the internet
23	It never came to mind to use my mobile device for such a purpose, when I purchased it.	No	communication between staff		SMS, MMS (Multimedia Messaging Service), E-mail	Primary (District Hospital and/or CHC/Clinic)	No, but I would not mind doing so	If I get financial reimbursement for using it, Better quality mobile devices, If I have a specifically designed mobile app, If I get trained to use it, I am curious about new technology, It makes my job easier, It contributes to better health care for patients, If x-ray images and lab results are accessible via the internet
24	No		Decibel 10th, CVT lite	free		All of the above	Yes, but it was only freeware, Yes, and I am using it for work purposes	If I get financial reimbursement for using it, If I have a specifically designed mobile app, It makes my job easier, It contributes to better health care for patients, If x-ray images and lab results are accessible via the internet
25	No	No			MMS (Multimedia Messaging Service), IM (Instant Messaging Service i.e. Whatsap or MixIt)	Primary (District Hospital and/or CHC/Clinic)	No, but I would not mind doing so	Better quality mobile devices, If I have a specifically designed mobile app, I am curious about new technology
26	No		Gestograma & Wheel pro	R15 each		Secondary (Regional Hospital)	Yes, and I paid for it , Yes, and I am using it for work purposes	If I get financial reimbursement for using it, Better quality mobile devices, If I get performance incentives for using it, If I have a specifically designed mobile app, It contributes to better health care for patients, If x-ray images and lab results are accessible via the internet
27	No					Secondary (Regional Hospital)	No, but I would not mind doing so	It makes my job easier, It contributes to better health care for patients, If x-ray images and lab results are accessible via the internet
28	Yes		Medscape, Qx, Skyscape, Eponyms	$0,99		Secondary (Regional Hospital)	Yes, but it was only freeware, Yes, and I am using it for work purposes	Better quality mobile devices, If I have a specifically designed mobile app, I am curious about new technology, It makes my job easier, It contributes to better health care for patients, If x-ray images and lab results are accessible via the internet
29	Yes	No	Medscape, Qx calculate		IM (Instant Messaging Service i.e. Whatsap or MixIt)	Secondary (Regional Hospital)	Yes, but it was only freeware	If I have a specifically designed mobile app, I am curious about new technology, It makes my job easier, It contributes to better health care for patients, If x-ray images and lab results are accessible via the internet
30	Yes	No	Medscape		IM (Instant Messaging Service i.e. Whatsap or MixIt), E-mail, WiFi	Primary (District Hospital and/or CHC/Clinic)	Yes, but it was only freeware	If I get financial reimbursement for using it, Better quality mobile devices, If I get performance incentives for using it, If I have a specifically designed mobile app, I am curious about new technology, It makes my job easier, It contributes to better health care for patients, If x-ray images and lab results are accessible via the internet
31	Yes		Medscape			Secondary (Regional Hospital)	Yes, but it was only freeware	It makes my job easier, It contributes to better health care for patients
32	No					Secondary (Regional Hospital)	No, but I would not mind doing so	It makes my job easier, It contributes to better health care for patients

APPENDIX F DATA FLOW EXAMPLE

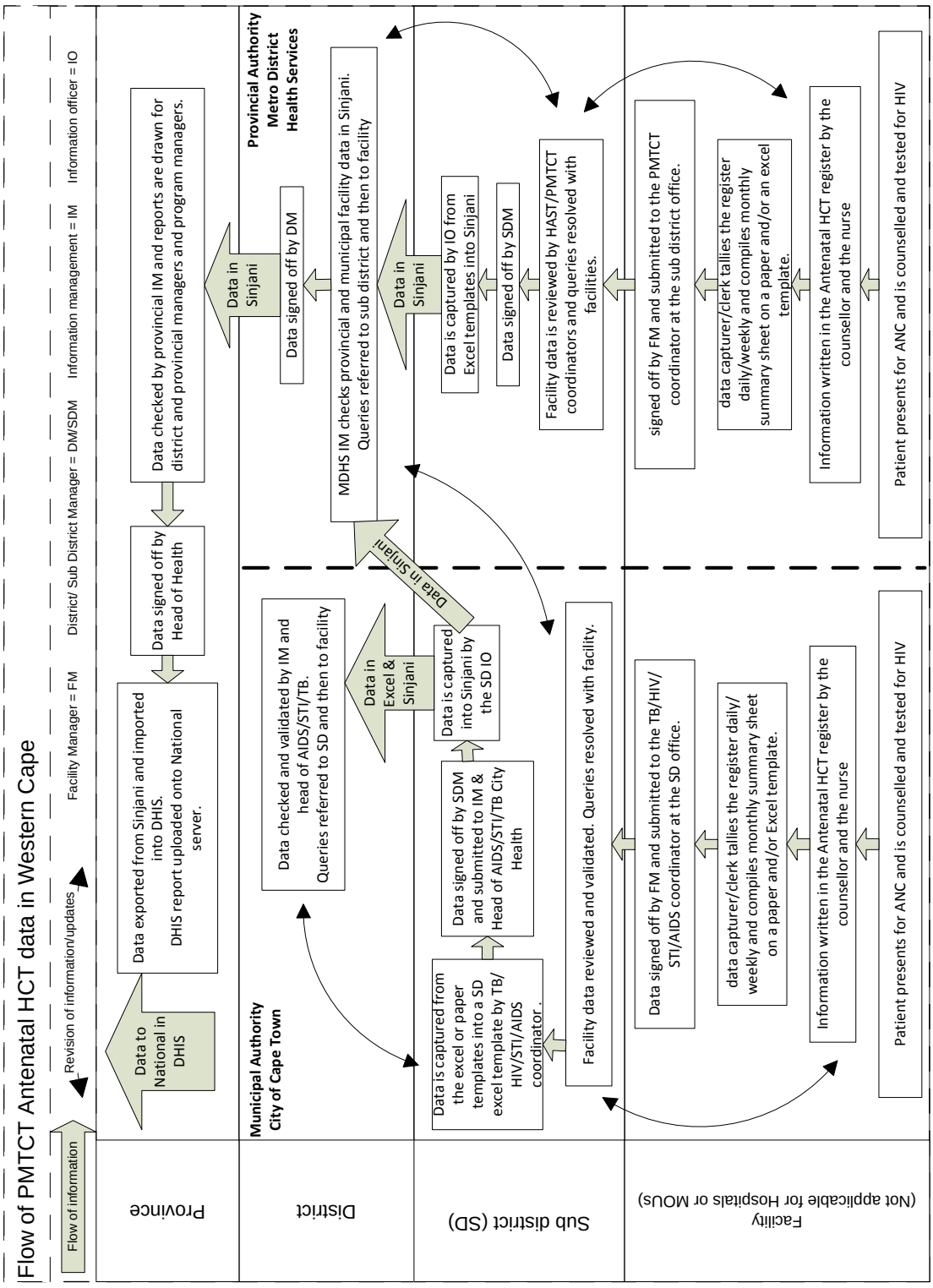


Figure F-1: Diagram of PMTCT data flow in the Western Cape

The diagram (Figure F-1) shows how PMTCT data regarding antenatal HIV counselling and testing (HCT) flows within the public health sector in the Western Cape. It can be seen that different systems and methods are used to capture data within municipal and provincial health facilities.

APPENDIX G INTERVIEWS

G.1 Summary of interviews

Table G-1 & Table G-2 shows summaries of the responses from the structured interviews conducted. In Table G-2 interviewees from Mezzanine and BroadReach did not consider themselves knowledgeable with business models to comment on the business models.

Table G-1: Summary of responses from interviews regarding the feasibility dashboard

Regarding the feasibility dashboard	*Mezzanine*	*BroadReach*	*MRC*	*WiGroup*
1. Is the feasibility study comprehensive in the areas covered?	yes	yes	Yes	partially
2. Are the results from the feasibility study accurate?	yes	yes	fairly	more references needed
3. Are the results relevant to the current industry?	yes	unproven	Yes	yes
4. Can the results be used to make general statements or infer principles beyond the research context?	yes	yes	only general statements	yes

Table G-2: Summary of responses from interviews regarding business models

Regarding the business models	*Mezzanine*	*BroadReach*	*MRC*	*WiGroup*
1. Is Osterwalder's business model canvas a relevant model to use?	-	-	Yes	yes
2. Is it clear how value is created in each business model?	-	-	Yes	yes
3. Are the descriptions used in the business models accurate?	-	-	Fairly	more elaboration required
4. Are the business models relevant to the current industry?	-	NHI unsure, vital for future implementation	Yes	yes
5. Are the business models comprehensive?	-	-	yes	more refinement and elaboration required
6. Can the results be used to make general statements or infer principles beyond the research context?	-	-	Somewhat	yes

From Table G-1 it can be seen that most interviewees responded positively to the posed questions. Table G-2 shows that the MRC and Wigroup interviewees responded positively. Due to the number of responses, the external validation for the feasibility framework is stronger than that of the business models that were developed.

The following section gives the responses for the interviews either as transcriptions or as e-mailed responses.

G.2 BroadReach

An audio recording was taken during the interview with Miekie Treurnicht from BroadReach Health care on 20 July 2013. Relevant sections of the interview were transcribed.

Transcription of interview

13:55 Miekie: Orals waar jy kommunikasie tussen jou pasient en kliniek wil he is mobile health n baie amazing geleentheid.

28:50 Miekie: Ek dink hulle het almal rekenaars. Management het meestal almal rekenaars. Hulle competency om daardie rekenaar te werk is n ander vraag.

38:10 Miekie: Jy gaan nie die healcare worker verander nie. So jy moet die stelsel verander om te pas by die healthcare worker. Obviously binne perke. […] Jou grootste problem is nie jou healthcare worker se changemanagement nie. […] hulle gebruik die tegnologie maar dis nie user friendly nie. […] of jy maak dit maklik, of hulle gebruik dit nie.

40:37 Miekie: Jou nurse gaan nie met haar selfoon voor die patient sit nie, hulle kan nie, hulle mag nie, hulle sal n massive problem kry – al weet die patient hulle is besig om in te tik. Want hulle gaan nou die mense SMS en whatever. So hulle [management] probeer eintlik om hulle [nurses] te kry om nie hulle selfoon te gebruik in hulle werk nie. […] dit maak n massive issue oop, want hulle kan dit dalk abuse. […] daar sit jy met n werks kultuur probleem.

41:35 Miekie: Jy gaan dit baie moeiliker track [data gathering]. Op die oomblik gaan wys jy die boek vir hulle [nurses] […] nou vra jy hoekom het jy nie daar ingevul nie. […] Nou kry jy daardie inligting op die rekenaar. Nou vra jy vir hulle hoekom het jy hom nie ingevul nie. Hulle gaan vir jou se dis nie my inligting nie. […] wie se vir jou dit was ek? […] hulle het nie die begrip van daai ding kom nou van die selfoon af na die rekenaar toe nie.

42:14 Miekie: Jou nurse populasie is n verskriklike born before technology (BBT) […] hulle is nie baie lief vir dit [mobile phones] nie. […]

42:44 Miekie: Iets wat blykbaar goed werk […] is daai Mobenzi ouens. Hulle community health worker ding werk. […] Die groot verskil is dat die health worker nie in n konsultasie proses is nie. […] Ek se nie dit gan of kan nie werk nie.

46:14 Miekie: Ek werk baie met die voorlopers van NHI. Met die bevondsing model nie so baie nie, maar wat ek weet is dat dit is vrek onseker vir almal. Hulle het nie n clue hoe hulle dit gaan doen nie. […]

46:53 Miekie: (regarding funding) Vir nou focus hulle [government] om die health system reg te maak vir NHI. So hulle [government] focus op quality services, en op hierdie CHW model, […] (as) PHC re-engineering outreach team deel (is van) NHI, (dan) ja.

47:41 Miekie: As dit (vaccination tracking) invleg in jou outreach team model in, wat dit wel kan doen, yes, dan sal dit ‘n deel van NHI kom. […] as hulle dit by outreach teams inslot, en die befondsing so wil kry deur NHI, dank an die NHI gelink word aan dit.

49:59 Miekie: NHI se befondsing gaan baie sterk in national core standards (NCSs) […] op die oomblik gaan n klomp geld gaan in recruitment, infrastructure, en general health system upliftment.

50:52 Miekie: Ek dink dit is redelik alle areas covered (feasibility framework), maar in die detail nie. […] Daar is nogsteeds n detail onder dit […] hoekom se jy dit. […] jy moet n goeie agtergrond he wat se hoekom is dit groen (feasibility indication).

53:10 Miekie: (on relevance to stakeholders) As jy […] vroer kan kyk na die impak wat dit kan he. […] Is hulle besig om die regte problem aan te spreek […] Dit beteken nie hulle gaan immunisation 100%

in die land kry nie. As hulle dit van 80 na 90 kan kry is dit ook welkom. […] Waar le die impak, en is die model wat hulle wil doen feasible op die area waar hulle die impak wil he.

51:47 Miekie: Ek is versigtig vir literatuur, jy moet baie mooi gaan kyk na watse populasie kyk jou literatuur na, veral as dit internasionale goed is.

55:16 Miekie: Ek dit dit is n redelike generiese mHealth ding [feasibility framework] […] jou verskil gaan kom by jou patients […] Die res is redelik generies mHealth […]

55:55 Miekie: Wat hulle nou doen, en dit het n groot risiko vir jou data capturing […] voor HIV het hulle die dokter ding gehad, toe het hulle die programs waar jy verskillende kamers het, nou […] nou hulle dit […] die super market approach of die integration of services. Nou is hulle terug by elke consultation room en elke nurse moet alles aanbied.

59:26 Miekie: Tensy hulle iets soorgelyk kan doen vir alles, n tipe application he waar hulle al hulle inligting op die foon insamel, dan kan dit semi werk, alhoewel hulle nie daarvan gaan hou nie.

61:62 Miekie: Jy gaan 'n verskillende strategie he vir privaat en publiek, jy gaan 'n verskillende bemarking hê. Public is altyd provider driven.

G.3 WiGroup

A telephonic interview was done with Ryan Goosen from WiGroup, where the research was explained and the results discussed with him. This was followed by him e-mailing the responses to the interview questions on 16 July 2013. The views expressed by Ryan Goosen do not necessarily reflect that of WiGroup.

Notes from telephonic interview

'Setting up a mobile service technical is not the difficult part.' ~ Ryan Goosen

What such a solution technically requires:

- Communication channels: USSD or SMS to Health care workers and parents
- HL7 interface
- Web portal for management

Things to consider for a mHealth solution:

- Built to scale
- Integration with current health system

'The business idea of an MHSV sounds viable.' ~ Ryan Goosen

Business model: also consider

- Commercialisation of MHSV.
- Reward / incentive for mothers and health workers.

'Working with advertisers can be tricky.' ~ Ryan Goosen

E-mailed responses

Regarding the feasibility dashboard

1. Is the feasibility study comprehensive in the areas covered?

Partially – [The Feasibility dashboard] provides a good cross-section of the pertinent components to consider for such an initiative. However, it is unclear which roles are included as 'Health care workers' and what the average ages of such professionals are. Both of these would need to be defined and elaborated on and associated with a statistic on mobile phone usage as a surrogate measure for mobile phone literacy to better support your argument. Furthermore, the statement

regarding 'Management lacks skills to analyse data' would need to be expanded upon with examples and further refined to include which sectors, and levels, of management are required to perform such a task.

2. Are the results from the feasibility study accurate?

Further references are required to comment on the accuracy of the feasibility study.

3. Are the results relevant to the current industry?

In general there are many mHealth initiatives that could be beneficial to the South African healthcare system. In principle, we'd expect the same successes experienced by similar developing nations with mHealth intiatives.

4. Can the results be used to make general statements or infer principles beyond the research context?

Yes, many of the factors described in [The Feasibility dashboard] will apply to the broader scope of mHealth projects in South Africa and in other developing countries with similiar healthcare systems.

5. General comments?

1. With regards to [Knowledge gap] - I'd suggest commenting further on which companies involved in mHealth initiatives have been approached and which literature databases & search terms have been used to support your statement regarding a knowledge gap.

2. With regards to [the Problem statement] - I'd suggest expanding on why 'current routine vaccinations are not sufficient' - it would be beneficial to state how they currently aren't working, and why that might be. You can then tie in why a mobile technology facilitated solution might be useful.

3. With regards to [the Policies and ethics feasibility] - I'd suggest having a look at the Lancet series on the South African healthcare system that was published in 2009. This series of papers will provide further insight into ICT Infrastructure and healthcare policy implementation.

4. With regards to [the Economic feasibility] - I'd suggest reading about the 'SMS For Life' mHealth initiative and how the private sector was able to facilitate a mHealth solution implementation. Perhaps this will give you ideas on how mHealth strategies can be collaborations between the private sector and public sector (Government) to create shared value.

5. I'd also suggest further defining which vaccination strategy is currently the most unsuccessful and focus on that - e.g. How is it currently done? What are the current issues? How can mHealth intervene? Also, It would be beneficial to include a full review on the current vaccination schedule and strategy / workflow that is in practice in both public and private.

6. Overall this is a good start. However, further referencing and concrete case studies / examples should be expanded upon in detail (where relevant) and presented to the reader. When addressing roles in the healthcare system it is a good idea to be specific on the particulars of each role, i.e. healthcare systems manager vs. 'management'.

Regarding the business models

1. Is Osterwalder's business model canvas a relevant model to use?

The 'business model canvas' is a good starting point for most technology-driven projects. As such, the use of Osterwalder et al's business model should suffice for this project.

2. Is it clear how value is created in each business model?

Yes - this should be refined further. I'd suggest reading up on the incentivization strategies used in prior mHealth projects. Furthermore, I'd strongly suggest delineating your business models into

those Apps that are driven by USSD technology (as this will probably form the majority of the user base in the public sector), and then those driven by smart phone technology (e.g Apple iOS Apps, Blackberry etc.)

3. Are the descriptions used in the business models accurate?

I'd suggest further elaboration on which organisations in each entity would be involved, e.g. instead of Government I'd suggest Department of Health etc. This is important as the value proposition has to appeal directly to each specific party as each has a specific interest and set of priorities.

4. Are the business models relevant to the current industry?

The business models are applicable to the current industry. How relevant they are would remain a question of the estimated efficacy of the mHealth initiative.

5. Are the business models comprehensive?

Further refinement and elaboration is necessary.

6. Can the results be used to make general statements or infer principles beyond the research context?

Yes, as previously stated the business model (in principle) could be used as a base for other mHealth initiatives of a similiar nature.

7. General comments?

I'd advise the following: Investigation of how to use incentivization strategies (once a particular vaccination implementation issue has been defined).

1. Differentiate between smart phones (Apps) / non-smart phones (USSD).

2. mHealth is a field that requires literature evidence to both support the need for it and to demonstrate it's efficacy. As such, I'd suggest expanding upon the feasibility aspect of your research to better inform and tailor your business models.

3. A major cost is going to be integration (technically and logistically) into the healthcare systems infrastructure. It is important to investigate how each province differs in it's setup of ICT (Healthcare IT) and how this might affect your costing and feasibility of down-stream analysis (for measuring efficacy).

4. In-app advertising could be an avenue of revenue, but could pose a challenge in a USSD setting (which may form a large component of your user base).

G.4 Mezzanine

An audio recording was taken during the interview with Casper Strydom from Mezzanine on 13 August 2013. Relevant sections of the interview were transcribed and follow. The views expressed by Casper do not necessarily express the opinion of Mezzanine.

3:16 Casper: Policy and ethics dink ek is die grootste een (hindrance). […] Die regalatoriese fences wat daarso is… dit vat net baie lank om ‘n stelsel in plek te kry. Daar is te veel mense wat dit moet goedkeur voor dit in plek kan kom. […] Daar is n klomp mense wat moet besluit of dit nou die pad is om te gan. […] Daar is klomp medical-legal dinge wat hulle moet nakom voor hulle iets kan goedkeur.

7:11 Casper: Die unions hou nie daarvan dat die workforce gemonitor word so nie. […] mense hou nie daarvan dat daar opgecheck word op hulle.

7:37 Casper: Ek stem saam met die Human factors wat jy hierso het.

8:13 Caper: ja die integrasie (Health information system infrastructure) is n problem.

8:40 Casper: daar is nie noodwendig n stelsel wat set in stone is nie, daar is nie n proven een wat werk nie. […] daar is nie n holistiese uitkyk oor hoe alles inmekaar steek nie.

10:06 Casper: Cost and funding. Dis nie almal wat n smartphone het om n application te run nie. So jy sal vir die health care worker n smartphone of tablet moet gee om die datacapturing te doen, en dit maak dit baie duurder. Op die einde betaal mens meer vir die device as wat jy vir die diens betaal.

11:02 Casper: Tegnies is dit nooit n problem nie, dis net al die ander dinge wat sukkel. […] Policy en ethics is vir my die grootste ding. Dan sal ek se information capturing want daar is nie noodwendig n huidige stelsel by facilities nie. En dan cost en funding, want mens kan altyd […] funding van iewers af kry. Dis eintlik iets wat baie maklik opgelos kan word. […] Iemand moet net die funding beskikbaar maak.

11:52 Casper: Human factors, ek sal nie se dat dit so erg 'n problem is nie, want enige iemand kan leer. Ek dink dit is eintlik manageable in daardie sin. […] Hierdie kan jy oplos met training en follow up training. […] Jy kan dit [human factors] maklik oplos met geld te he en training.

12:55 Casper: Relevant to the current industry – Ja. Information capturing op die micro en meso level is n problem, want die mense weet nie noodwendig wat hulle stelsel is by hulle onderskeie facilities nie. Ek is seker daar is soos n guideline, maar hoe erg dit geimplementeer word is ek nie seker oor nie.

14:10 Casper: Dit kos dieselfde geld om so stelsel vir een fasiliteit ops te stel as om dit op te stel vir 10 000 fasilitiete. Die technologie is scalable, daar moet net n business case daarvoor wees.

15:16 Casper: (generalizable) Jy kan hierdie afleidings maak vir health in general, nie net vaccination gebaseerd nie. On focus nie net op vaccination nie, maar op alle chronic deseases wat daar is. Dit het dieselfde prent as wat jy hierso uitlig.

17:00 Casper: Dis belangrik om hierso iewers net te noem dat so n stelsel… dis nie nootwendig n application wat geskryf word en dan los jy dit by n fasilitet en dan moet hulle dit gebruik nie. Dis nie n produk nie, dis meer n diens wat gelewer moet word. […] Daar moet continuous support wees van die maatskapy wat die stelsel in plek sit. […] daar moet n dedicated support nommer wees wat hulle kan bel.[…] Jy kan nie net iets vir iemand gee en verwag hulle moet dit gebruik nie, jy moet hulle druk in die regte rigting. Dit moet bietjie meer van n partnership wees as n klient en vervaardiger […] daar moet defnitief n follow up process en support processes in plek wees. Dis n SLA (service level agreement) wat onderteken moet word tussen die department van gesondheid en die company. […] daar moet n implementation strategy wees van hoe gaan jy hier die in die veld insit.

20:12 Casper: Regdeur moet die klient in die loop gehou word van wat gebeur.

22:42 Casper: Ons revenue steam is die per user per month fee vir die application. Dis die department of NGO wat dit betaal (nie end user nie).

24:52 Casper: Vodacom bill dit (mHelath application) as n value added service (VAS) op die kontrak.

16:52 Casper: (on business model) iets anders as health insurance, soos n private company, kan ook n klient wees.

31:16 Casper: Ek is nie enigstens betrokke met business models at all nie. […] dis nie iets wat ek doen op n dag tot dag basis nie.

G.5 MRC

Jill Fortuin completed the questionnaire of the interview, and responded via e-mail on 13 August 2013.

Regarding the feasibility dashboard

1. Is the feasibility study comprehensive in the areas covered?

Yes, see comment[…]:

“Mention instances where mobile phones are used in the public sector, e.g. getting an ID, paying chil support grants etc.”

2. Are the results from the feasibility study accurate?

Fairly accurate, you would need to include actual stats and legislation where necessary

3. Are the results relevant to the current industry?

Yes

4. Can the results be used to make general statements or infer principles beyond the research context?

No, possibly make general statements but not use principals generaically until a more in depth feasibility study takes place

5. General comments?

[None]

Regarding the business models

1. Is Osterwalder’s business model canvas a relevant model to use?

Yes

2. Is it clear how value is created in each business model?

Yes

3. Are the descriptions used in the business models accurate?

Fairly accurate, under value proposition more can be said about infant mortality in South Africa due to the lack of immunization and growth monitoring in the first six weeks.

4. Are the business models relevant to the current industry?

Yes, although we know that government never has money so it would be useful to mention the role of pharmaceutical companies, large organizations like UN and the role they play in the business model and how they could benefit.

5. Are the business models comprehensive?

Yes

6. Can the results be used to make general statements or infer principles beyond the research context?

Somewhat, I extremely cautious to do so with empirical evidence

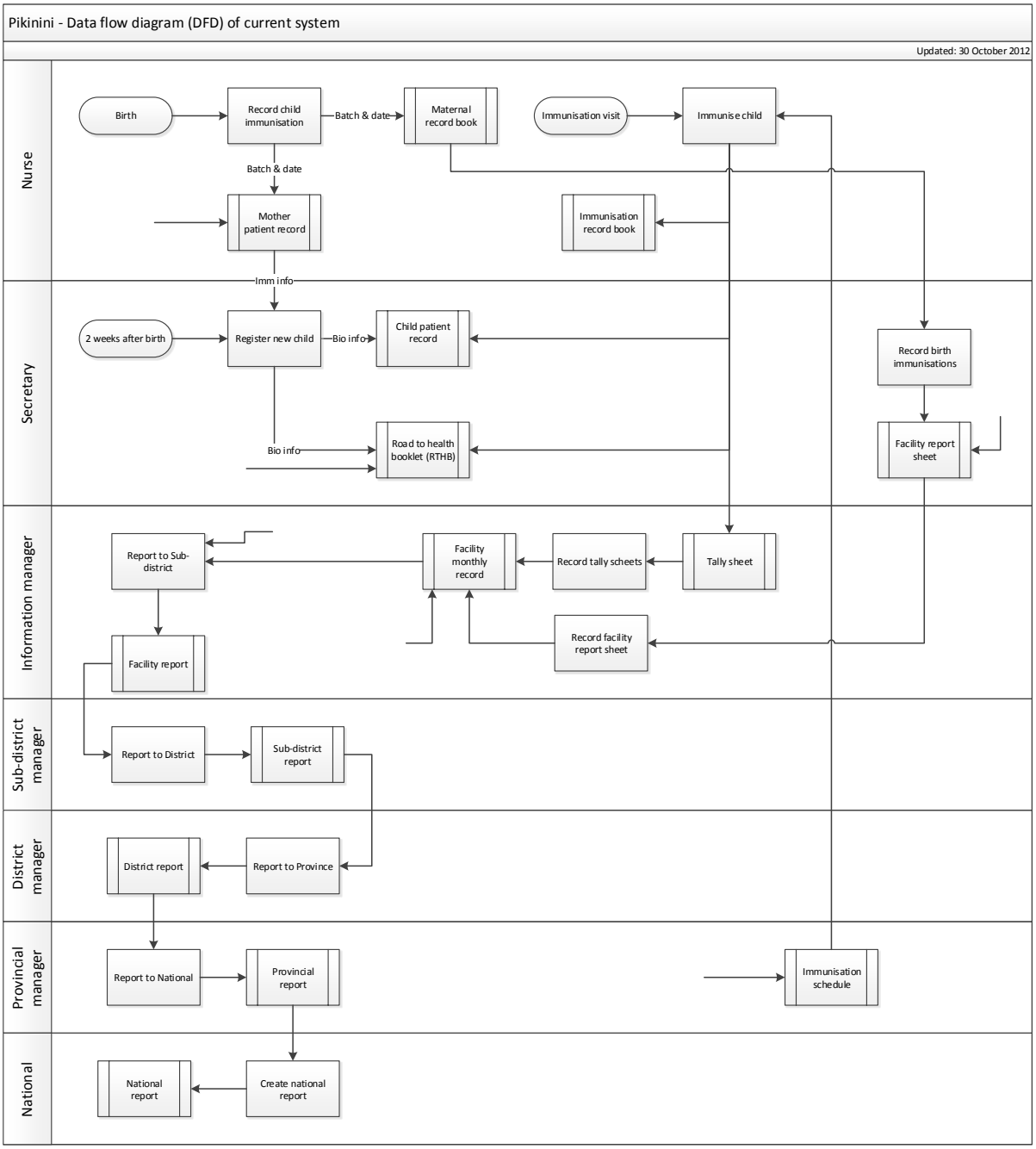
7. General comments?

[None]

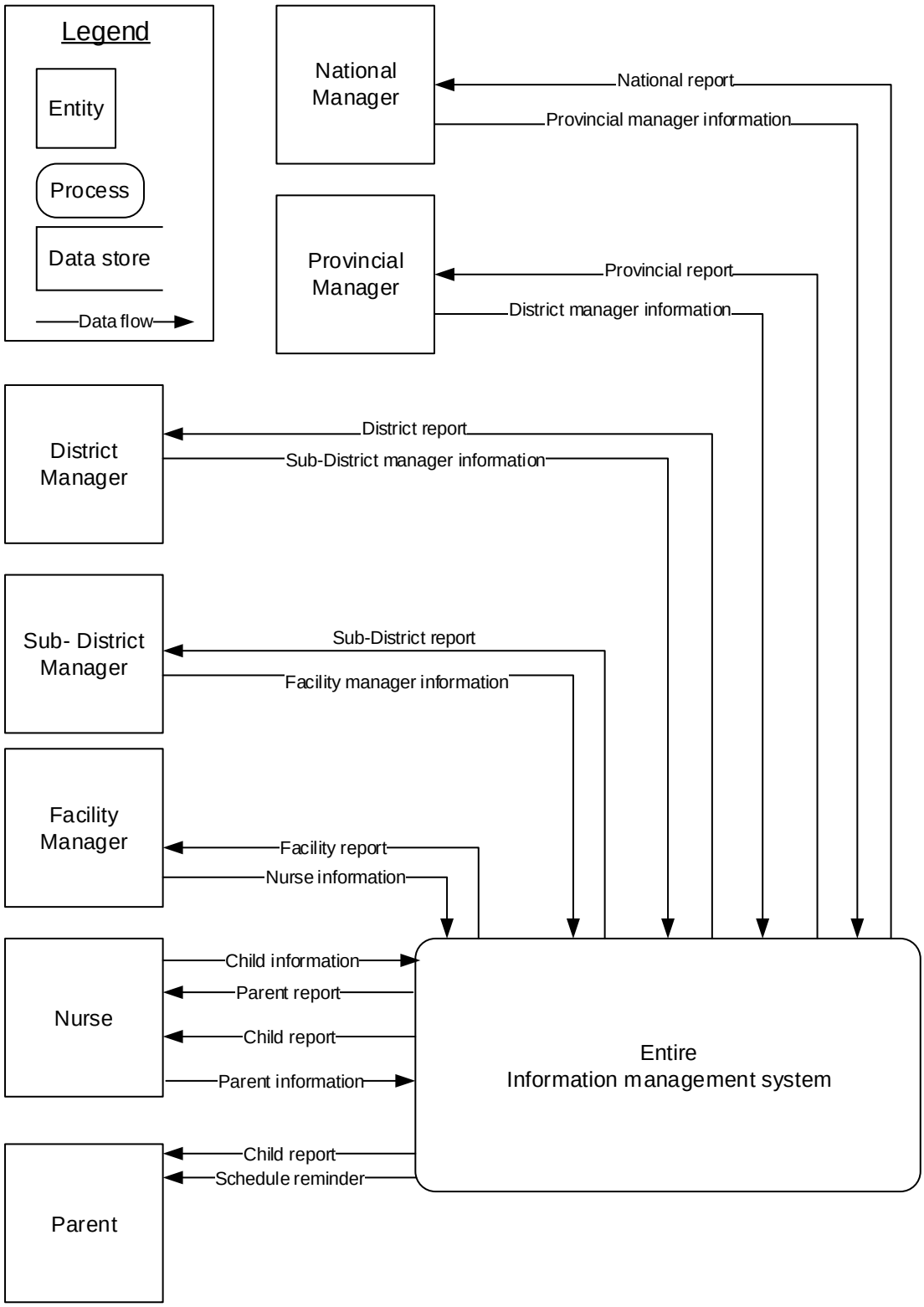
APPENDIX H PIKININI

The case study of the Pikinini project is given in Section 5.4. The following diagrams given more detail on the system design of the project.

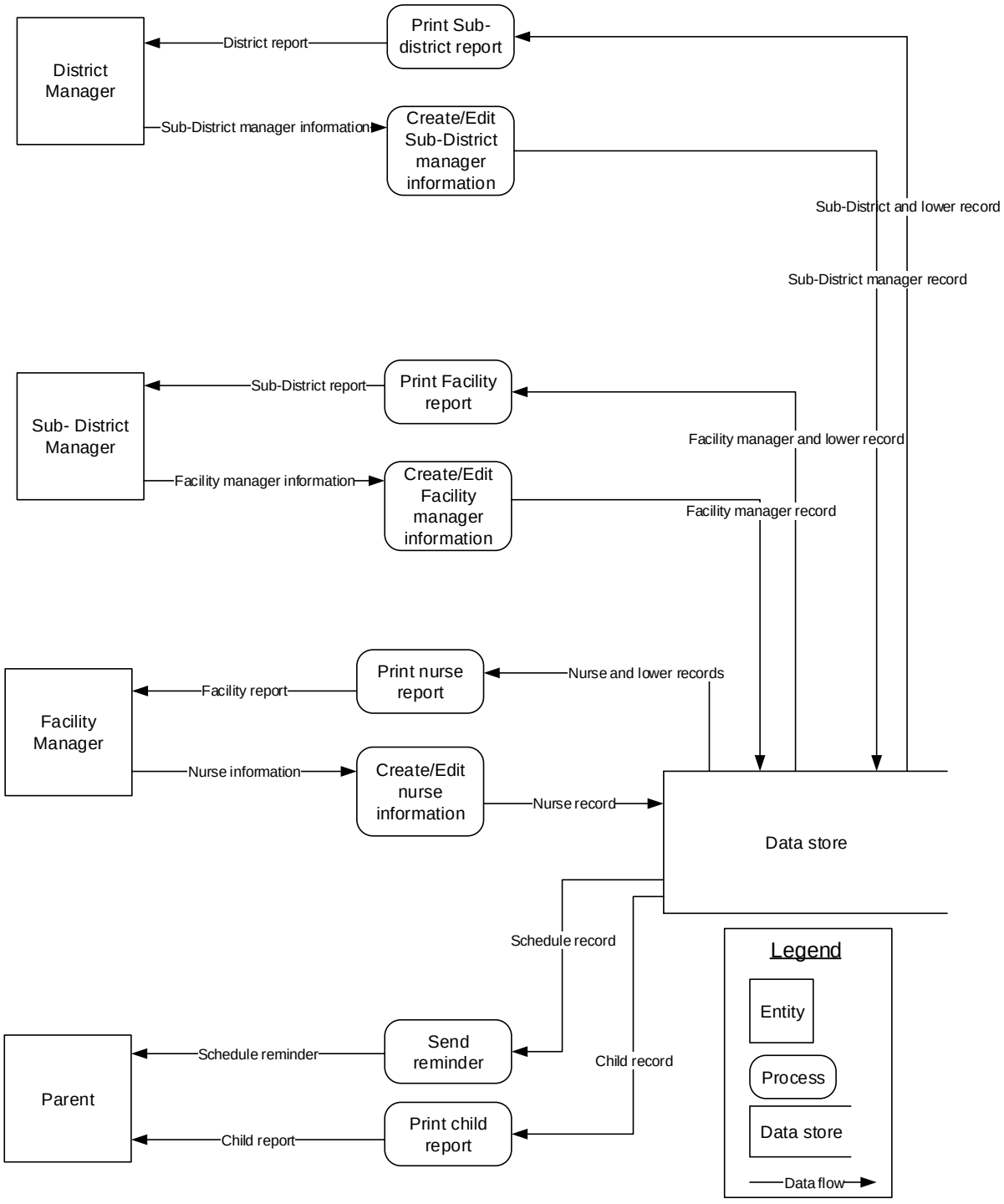
H.1 Data flow diagram of current system



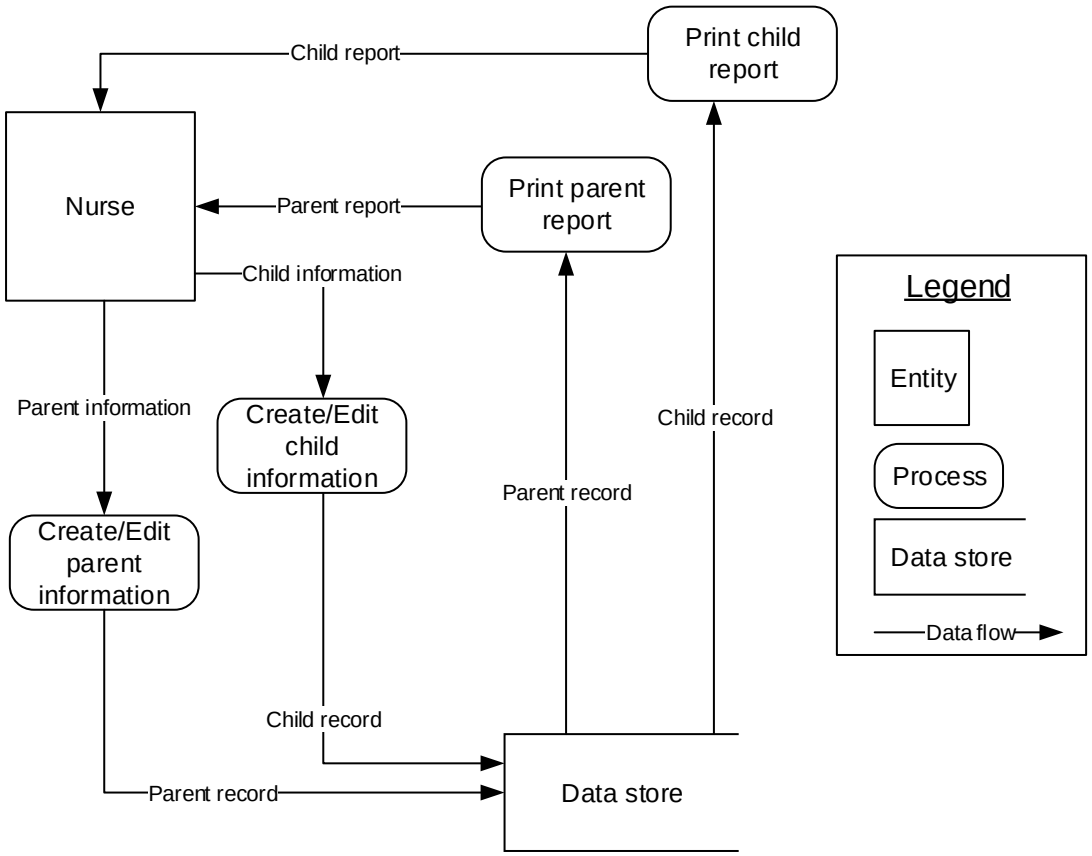
H.2 Pikinini data flow diagram: overall



H.3 Pikinini data flow diagram: managers and parent

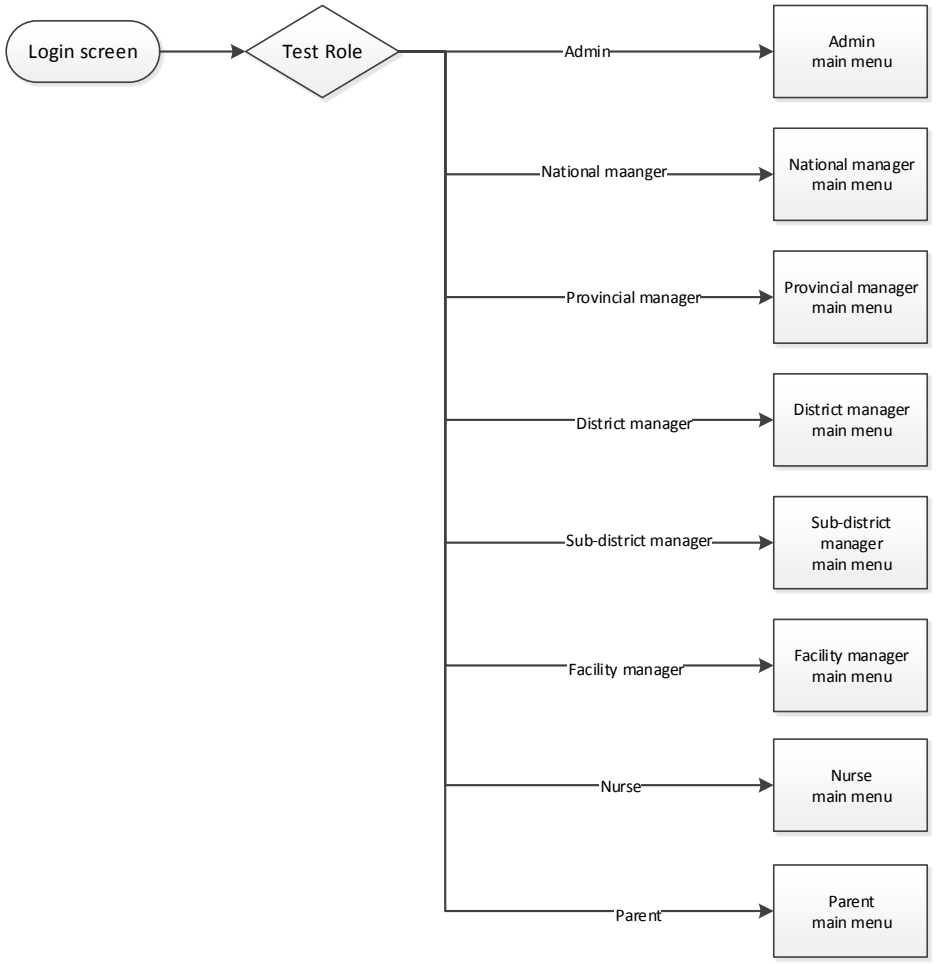


H.4 Pikinini data flow diagram: nurse

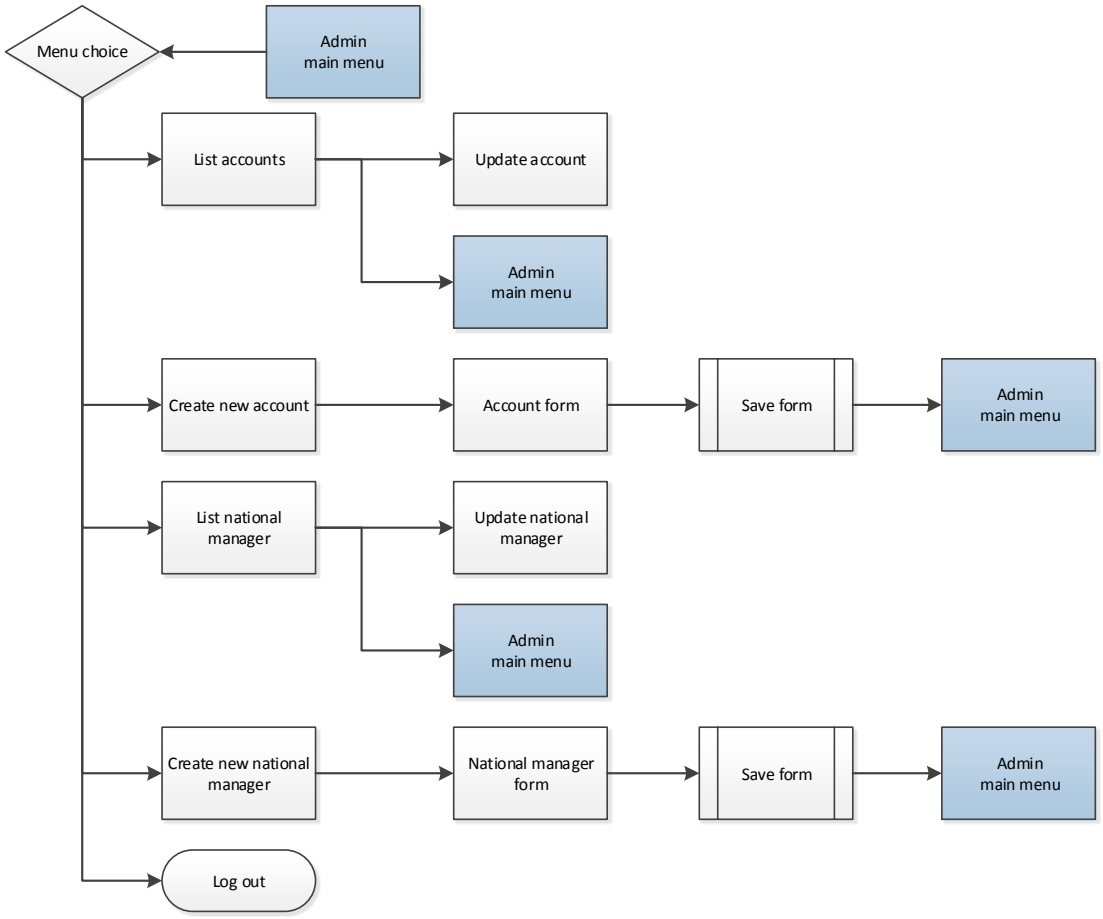


H.5 Pikinini user interface flow diagram

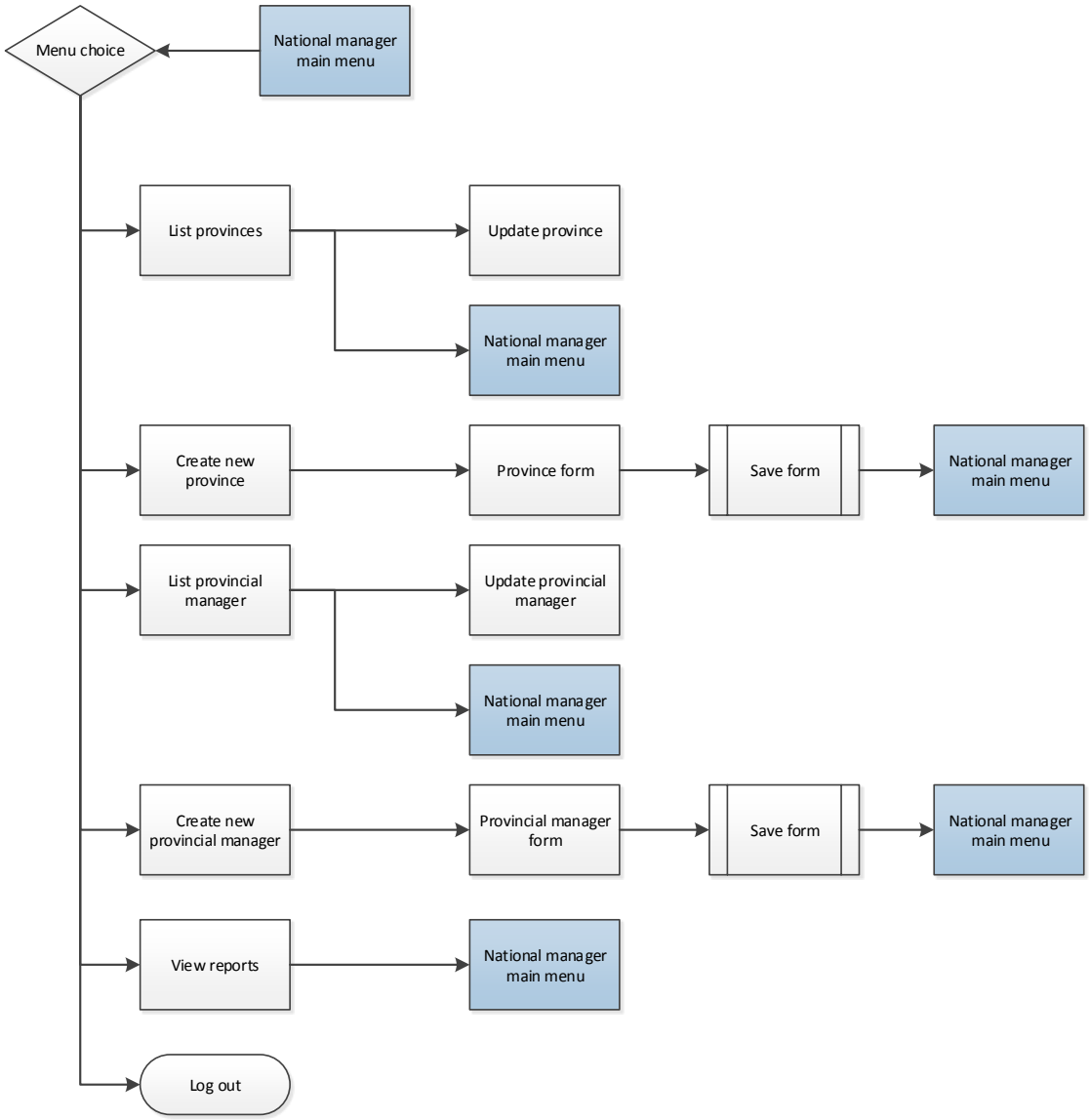
Pikinini	Process: Login screen	13 Nov 2012
	Role player(s): All	



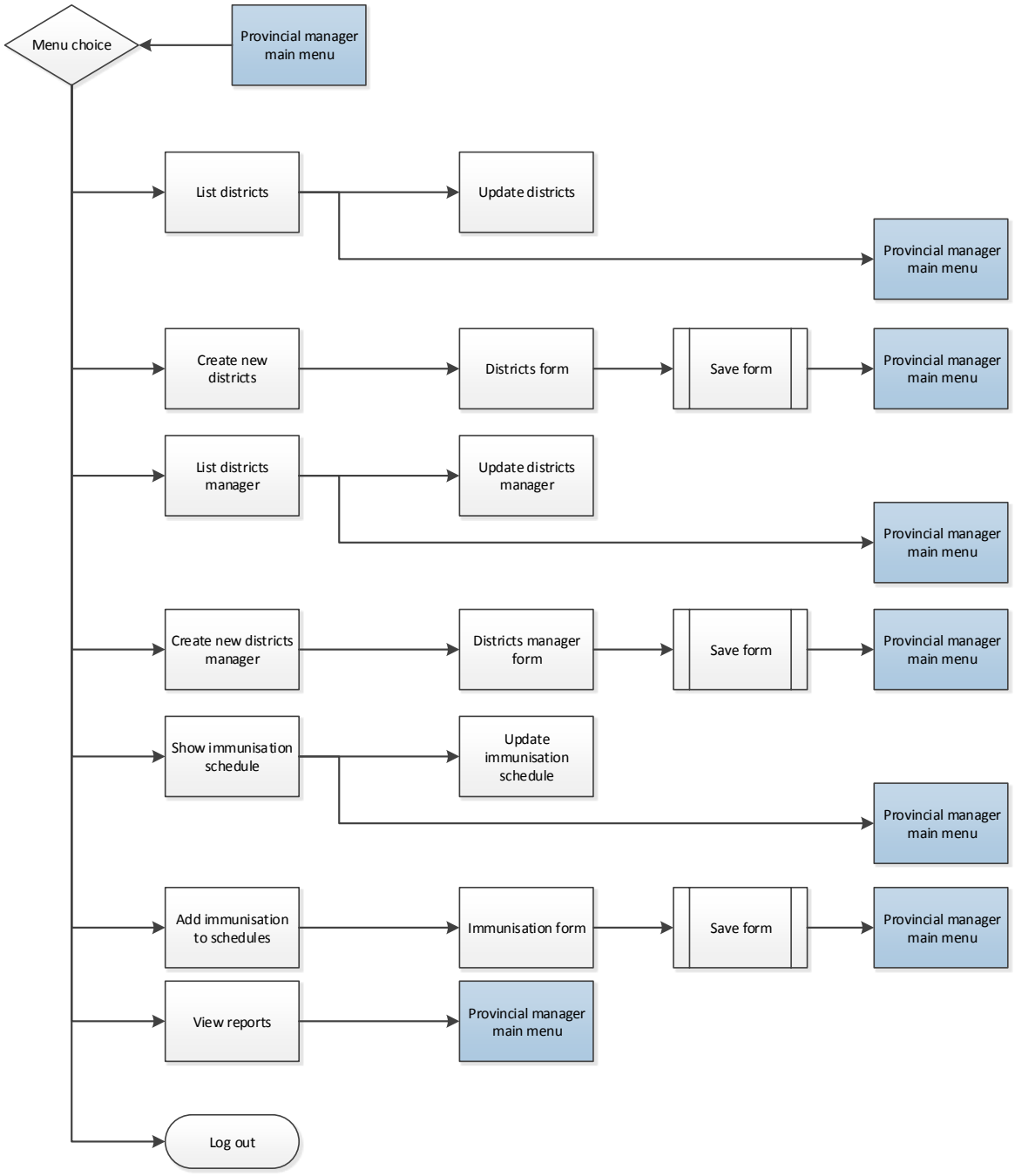
Pikinini	Process: Admin main menu	13 Nov 2012
	Role player(s): Admin	



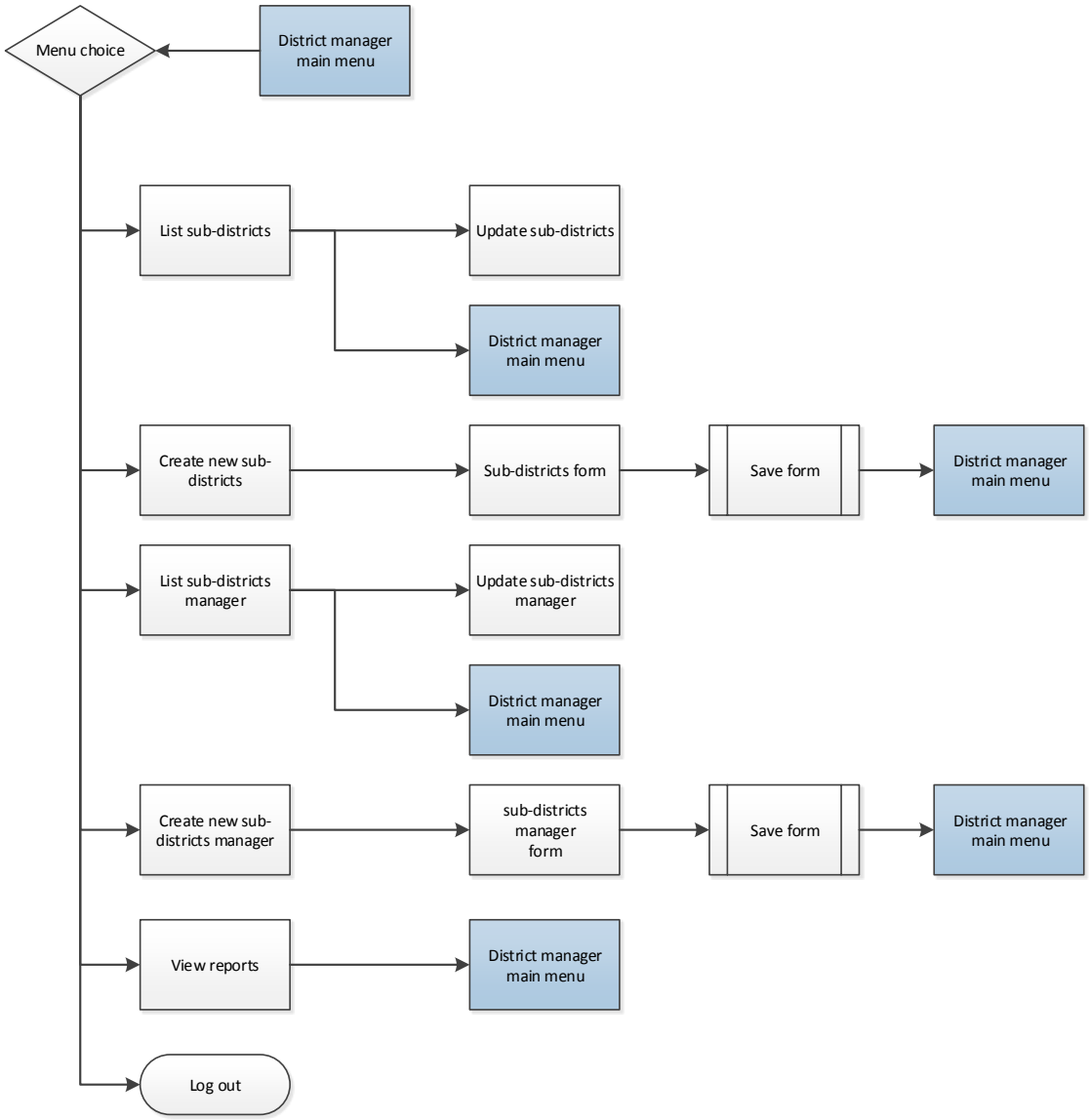
Pikinini	Process: National manager main menu	13 Nov 2012
	Role player(s): National manager	



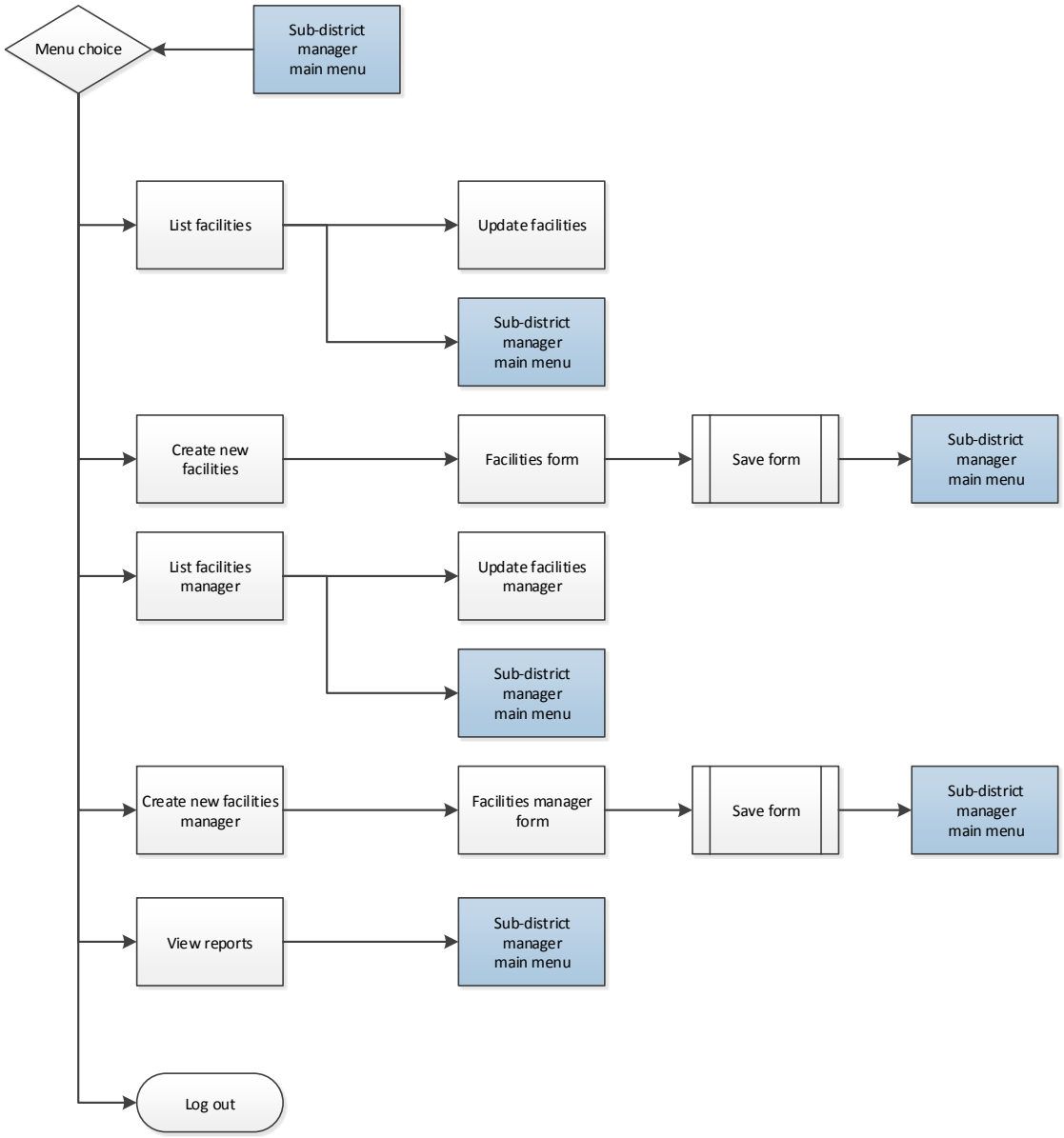
Pikinini	Process: Provincial manager main menu	13 Nov 2012
	Role player(s): Provincial manager	



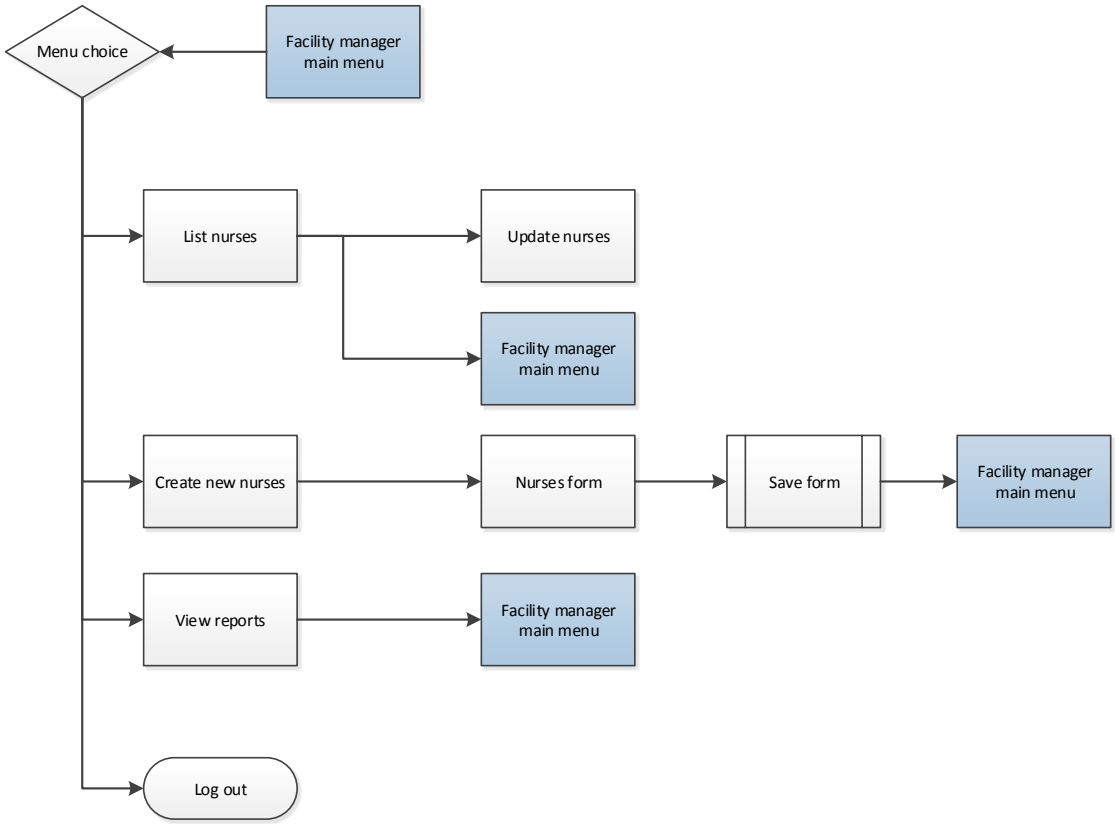
Pikinini	Process: District manager main menu	13 Nov 2012
	Role player(s): District manager	



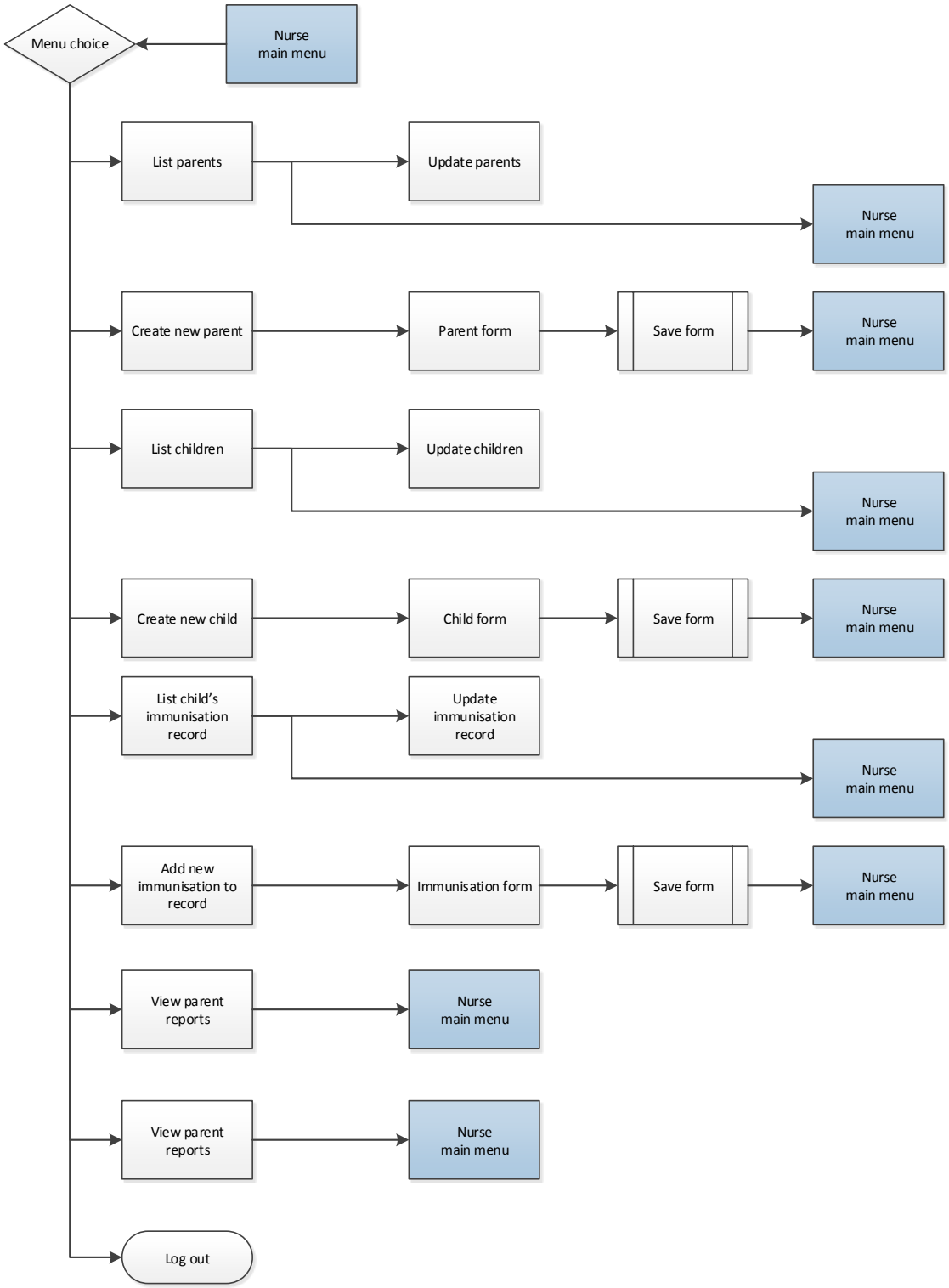
Pikinini	Process: Sub-district manager main menu	13 Nov 2012
	Role player(s): Sub-district manager	



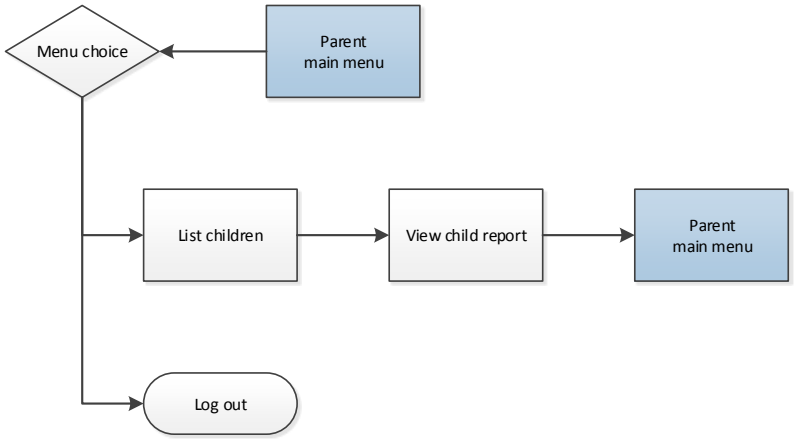
Pikinini	Process: Facility main menu	13 Nov 2012
	Role player(s): Facility manager	



Pikinini	Process: Nurse main menu	13 Nov 2012
	Role player(s): Nurse	



Pikinini	Process: Parent main menu	13 Nov 2012
	Role player(s): Parent	



APPENDIX I SAIIE PAPER [153]

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ASSESSING THE TECHNOLOGY ACCEPTANCE OF CELL PHONES
WITHIN THE CONTEXT OF THE PRIMARY HEALTH CARE SYSTEM OF SOUTH AFRICA

F.J. Snyders[1]* and L. van Dyk[2]
[1]Department of Industrial Engineering
University of Stellenbosch, South Africa
franslight@gmail.com mailto:14581264@sun.ac.za

[2]Department of Industrial Engineering
Stellenbosch University, South Africa
lvd@sun.ac.za

ABSTRACT

The use of cell phones for health services and communication (mHealth) can potentially strengthen health systems in South Africa. This study is particularly concerned about the feasibility of cell phones to address the problem of limited access to health care in South Africa.

One of the success factors in the use of technology for service innovation is the degree of technology acceptance. The acceptance of mHealth in the South African context is not known.

The technology acceptance model (TAM) can be used to evaluate mHealth acceptance in South Africa. In this paper the evolution of the technology acceptance model (TAM) is reviewed, together with variations of the model that is applicable to mHealth services. A pilot study was performed in the private health care sector of the Western Cape, which showed a mean neutral response to using mHealth. Strong notions against using mHealth balanced as many positive notions towards using mHealth.

Future work includes a full scale study considering elements from both the TAM, together with e-business adoption elements.

* Corresponding Author

CONTENTS

1 INTRODUCTION

1.1 What eHealth and mHealth?

1.1.1 eHealth

The word "eHealth" (also written e-health) comes from a combination of "health" and the "e" in electronic. The term was first used by with other "e-words" to convey the new opportunities that the Internet could bring to healthcare [1]. A variety of definitions exist for eHealth, and no standard definition has been agreed upon. From a systematic review of published definitions [2] two universal themes of "health" and "technology" was identified. For this study, the definition from Vital Wave Consulting [3] is used, namely "the use of information and communication technologies (ICT) for health services and information."

1.1.2 mHealth

The word "mHealth" (also written m-health or mobile health) is the combination of "health" and the "m" in mobile. The term was first defined in 2003 by Istepanian [4] as "the exploitation of the mobile telecommunication and multimedia technologies and their integration into new mobile health care delivery systems". mHealth form part of eHealth, seeing that mobile phones are part of ICT. The definition for mHealth used for this study is also from Vital Wave Consulting [3] used, being "the use of mobile communications for health services and information".

1.2 A problem in South African healthcare

In 2002 the UN launched the Millennium Development Goals (MDGs) which define various targets for nations to reach by 2015. Three of these goals are health related [5]:

- MDG4: Reduce mortality of children under 5 years of age (target two-thirds reduction 1990–2015)
- MDG5: Improve maternal health (target three-quarters reduction of maternal mortality per 100 000 live births 1990–2015)
- MDG6: Combat HIV, AIDS, malaria, and other diseases

From 1990 – 2009 South Africa has shown a reversal of progress on MDG 4, with no progress on MDG 5, and insufficient progress on MDG 6 [6]. In 2009 child mortality was 69 per 1000 live births, with maternal mortality being 400–625 per 100 000 live births [7].

The primary health care system of South Africa has limited resources to address these health care needs. With only 0.13 doctors per 1000 patients and 1.9 hospital beds available per 1000 patient in the public sector [8], access to health care in South Africa is limited.

1.3 Potential of mHealth to address this problem

The large scale uptake of mobile phones has created a platform that can be exploited to increase access to healthcare services and information. Mobile phones are able to reach further than any other technology or health infrastructure [3]. In South Africa over 99% of the population is covered by a mobile phone network [9], with 90% of households having a functional mobile phone in their dwellings [10].

Both the United Nations (UN) and the World Health Organization (WHO) have recognized the potential of using mHealth [11]. In a global survey on mHealth [3] 112 countries reported at least one mHealth initiative.

With mHealth being a new development, concrete evidence is still growing to show the benefit of using mHealth. Thus far, the following benefits have been shown [3]:

- Increased access to healthcare information
- Improved ability to diagnose and monitor sicknesses
- The delivery of health information that is both more appropriate and applicable
- Increased access to continual training for health workers

1.4 Technology acceptance

Even though the need for mHealth services exists, the acceptance of using cell phones for health care services has to be investigated. One model that is extensively used for technology acceptance prediction is the technology acceptance model (TAM). The main factors for the TAM's wide spread use is given below: [12]

1. It is economical, IT-specific, and offers adequate explanation and prediction on diverse populations in diverse contexts
2. It is grounded in sound theory with well researched and validated psychometric scales
3. It has gained much empirical support for its explanatory ability and has become a leading model for acceptance of technology.

2 PURPOSE AND METHODOLOGY

The purpose of this paper is to investigate the assessment of technology acceptance for cell phones within primary health care system of South Africa.

This accomplished firstly through a review of the technology acceptance model (TAM), together with variations of the model that is applicable to mHealth services. Secondly, a pilot study is described in which a technology acceptance questionnaire was administered amongst a sample of private health care facilities in the Western Cape.

Future work is described, including the model that will be used to assess technology acceptance of cell phones.

3 TECHNOLOGY ACCEPTANCE MODEL (TAM)

3.1 Origins

The technology acceptance model (TAM) was first proposed by Fred Davis in 1985, based on the Theory of Reasoned Action by Fishbein and Ajzen [13]. The model suggested that motivation to use a system can be explained by three factors: Perceived ease of Use, Perceived Usefulness and Attitude towards Using [14].

In 1989 Davis, Bagozzi and Warshaw modified TAM to include the variable "behavioural intention to use". After a longitudinal study in 1989 they concluded that perceived usefulness (PU) and perceived ease of use (PEOU) have a direct influence on behavioural intention (BI), thus eliminating the need for the attitude towards using variable. The TAM was finalized in 1996 by Venkatesh and Davis into the model as shown in Figure 1.

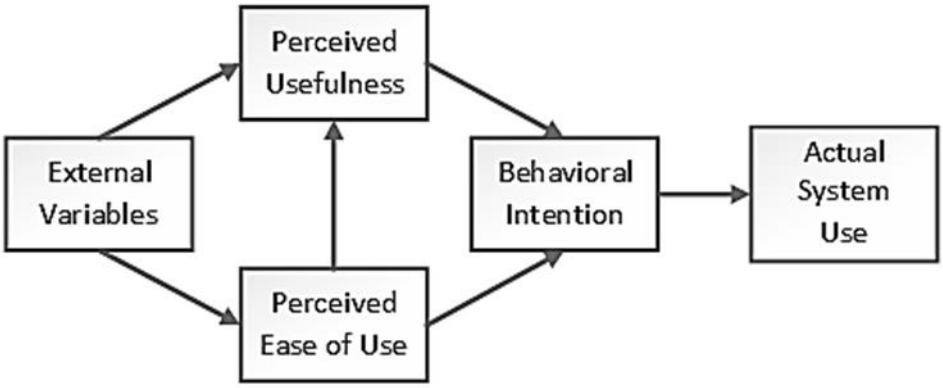

Figure 1: Final version of TAM [14]

3.2 Development

Although TAM predicted system usage, it could not explain the reasons behind users' perception of system usefulness. In 2000 Venkatesh and Davis [14] addressed this limitation by developing TAM 2 which includes additional variables that act on perceived usefulness (PU). They continued to work on TAM by including variables in an extended model of TAM in 2000 to explain factors that act upon perceived ease of use (PEOU) [15].

In 2003 Venkatesh, et al [16] combined previous research on information technology acceptance into the unified theory of acceptance and use of technology (UTAUT).

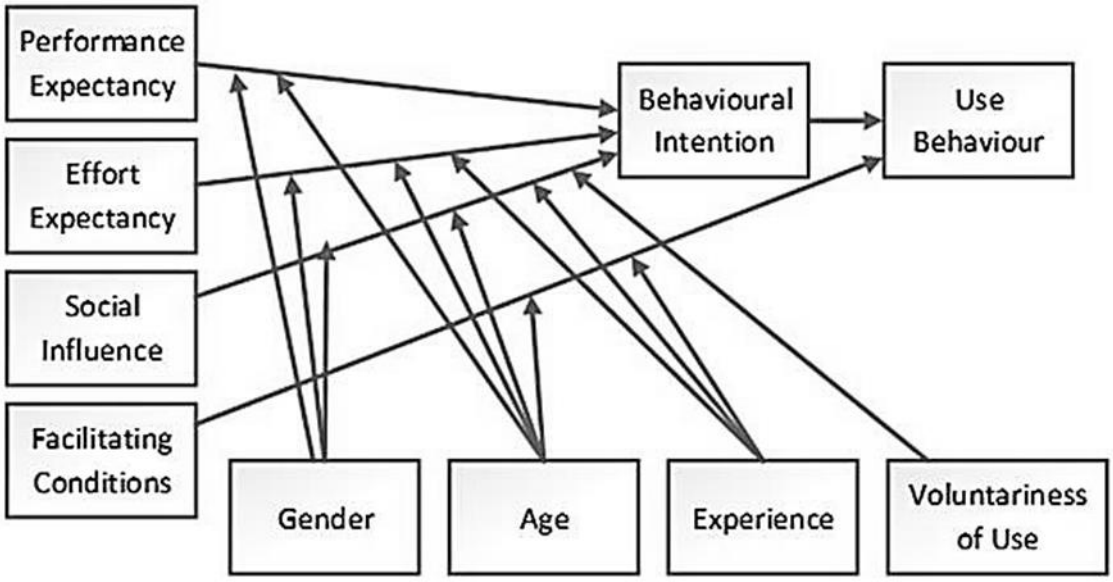

Figure 2: The Unified Theory of Acceptance and Use of Technology (UTAUT) [16]

A study by Cilliers and Flowerday [17] applied the UTAUT to health information systems in the Eastern Cape Province. A population of clinics were surveyed with telemedicine systems already implemented. Results showed that social influence and facilitating conditions influenced acceptance of using telemedicine. Lack of awareness and lack of knowledge were identified as barriers to implementing telemedicine.

3.3 Extensions

The TAM has been extended or combined with a variety of models in order to describe technology acceptance in a diversity of fields. In the research field of cell phones, mobile commerce has received a lot of attention [18]. Models extending TAM has also been developed for mobile commerce [19], but this study focusses on the field of using cell phones for health care. Applicable models are hence reviewed.

3.3.1 E-Health

Vance and Lankton [20] tested the TAM, motivational model and an integrated model (Figure 3) on users registered for an e-health service. It was found that all three models predicted behavioural intent well. The integrated model did not predict behavioural intent better that the other two models. Perceived usefulness extrinsic motivation (PUEM) was common for the models and predicted 68% of the variance in the behavioural intention (BI).

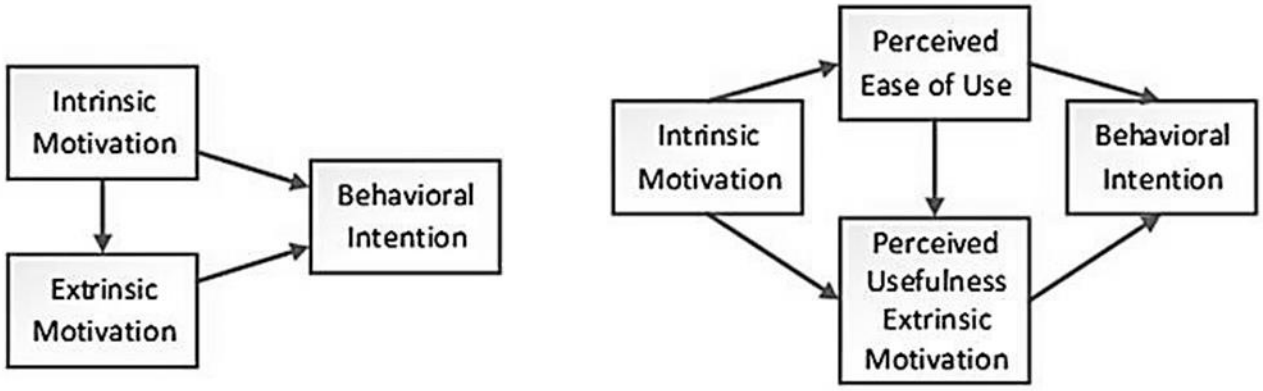

Figure 3: Motivational model (left) and integrated model (right) [20]

The above study showed that perceived usefulness (PU) is a major predictor of behavioural intention (BI).

3.3.2 Mobile service

López-Nicolás et al. [21] extended the TAM in order to describe user acceptance of mobile services (Figure 4). Variables related to the theory of diffusion of innovation (DOI) were included in the model, in term of social influences. All relationships were found significant except between perceived status benefits and perceived usefulness.

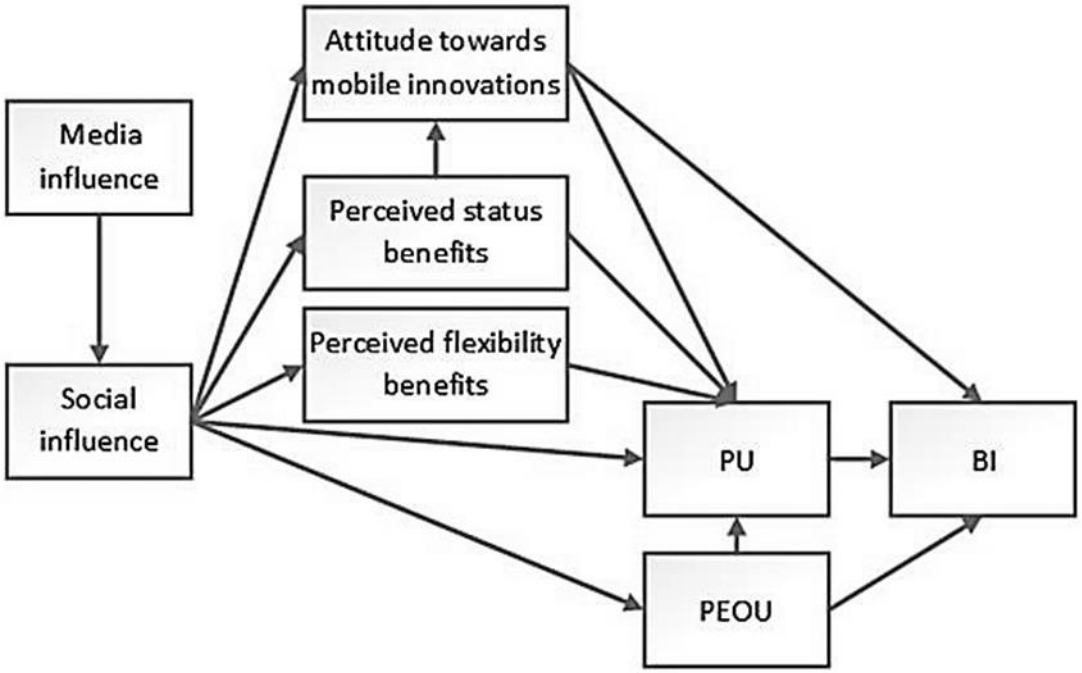

Figure 4: Concept model for mobile service acceptance [21]

The above show that attitude towards innovations have a significant influence on behavioural intention (BI).

3.3.3 Mobile health care

Wu et al. [22] combined the TAM with the model from theory of planned behaviour in order to describe hospital professionals' acceptance of mobile health care (Figure 5).

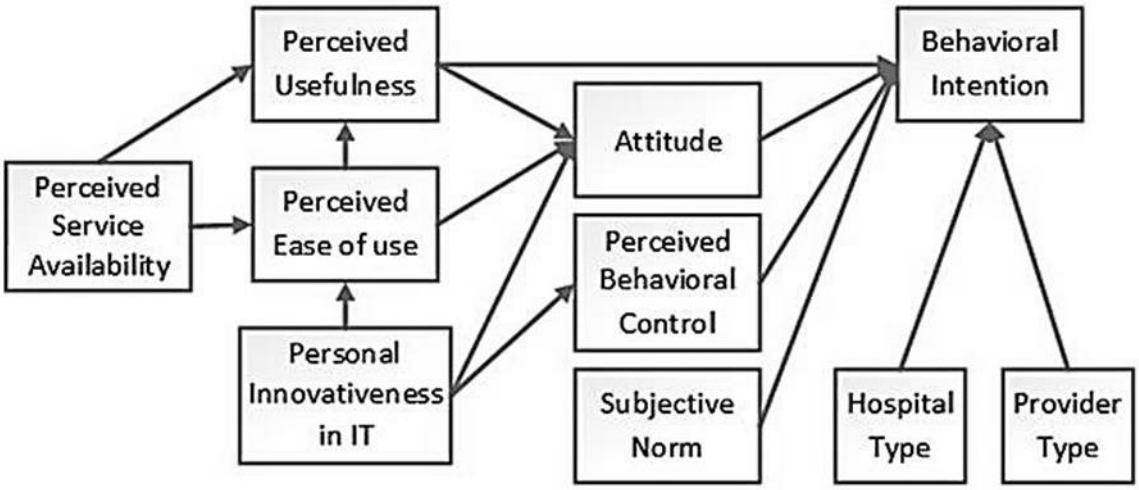

Figure 5: Adoption model for mobile health care [22]

Significant influences of the behavioural intention antecedents were reported. Perceived usefulness in particular was found to be a key factor in promising the use of mobile health care. Larger hospitals were also found to have a higher intention to use mobile health care, likely due to resource availability and responsibility for quality health care services.

3.4 Summary

TAM is a flexible tool to use, and has good empirical evidence for predicting technology acceptance. For the field of mobile health care TAM has been adapted for the specific context. Additional variables have been included to better predict behavioural intention.

4 PILOT STUDY

A pilot study was done in order to explore the South African environment for mobile health care services.

4.1 Method

The population for the pilot study consisted of private health care facilities, with pharmaceutical businesses making up most of the respondents. Surveys were given through e-mail or telephonically.

The survey was based on the integrated model (See section 4.3.1), to investigate a broader field of "using mobile phones for work purposes in health practices". The model considers the factors behavioural intention (BI), internal motivation (IM), perceived ease of use (PEOU), and perceived usefulness external motivation (PU-EM). Statements were created to describe these factors for which respondents rated their level of agreement to the statements. The scales reached from 1-7 ranging from strongly disagree to strongly agree, with 4 being neutral.

4.2 Results

Of the 83 surveys that were sent out, 13 surveys were completed in full, with one incomplete survey being discarded. Hence, the response rate was 15%. Table 1 shows the results from a descriptive analysis of the responses, with Figure 6 showing a frequency analysis of responses.

Table 1: Pilot survey descriptive results

	Median	Inter Quartile Range	Positive responses
BI	4	5	38%
IM	4	4	43%
PEOU	5	3	60%
PU-EM	4.5	5	50%

From Table 1 it can be seen that the medians for the factors were neutral or near neutral. The behavioural intention had the least positive responses, showing an overall neutral or negative response. The perceived ease of use had a small inter quartile range, with the most positive responses. This shows that a high perceived ease of use does not necessarily reflect a high behavioural intention. Perceived ease of use may be a qualifier for behavioural intention in this context of cell phone usage.

From Figure 6 it can be seen that responses were either strongly negative or positive skewed to the right. Perceived ease of use (PEOU) received the highest positive ratings, with perceived usefulness external motivation (PU-EM) receiving the most negative responses.

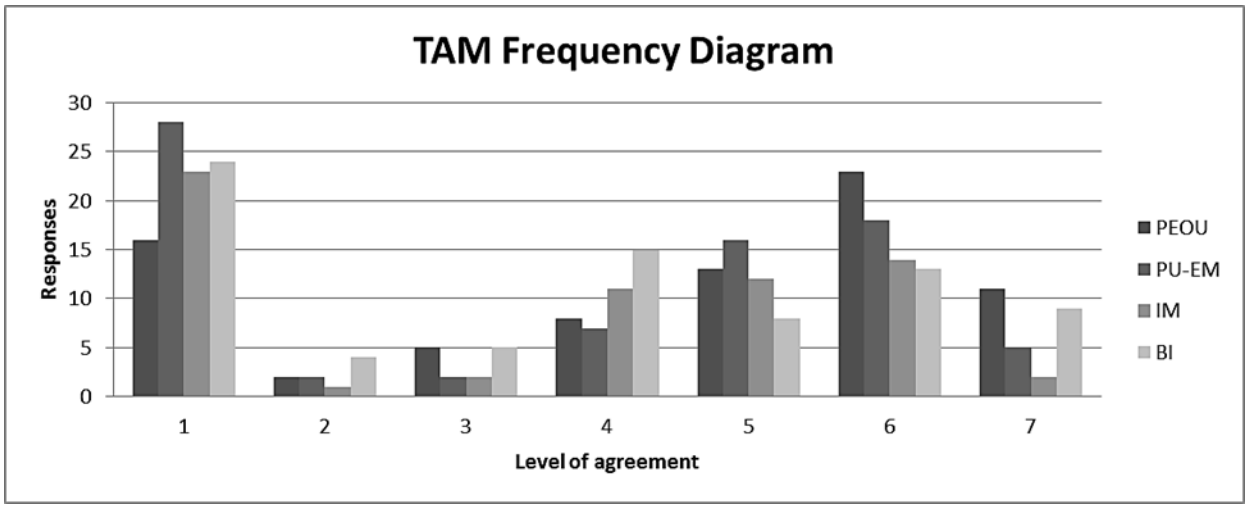

Figure 6: Frequency analysis of responses

4.3 Discussion

The percentage of respondents could be increased with more rigorous screening of potential respondents. The pilot study showed neutral median responses, with strong opinions for those that were against the use of cell phones for work purposes. Behavioural intention was not found strongly positive, even though perceived ease of use was found mostly positive.

Additional comments from the surveys showed that some employees were not allowed cell phones at work, and that some managers were strongly against the use of cell phones by employees. Other managers indicated that they saw no need for cell phones at work, seeing that they have sufficient ICT infrastructure. This could explain some the strong negative responses.

5 FUTURE WORK

In view of pilot study, the research focus of the full scale study will be from the perspective of health care institutes regarding the exploitation of the customer's cell phone for providing value adding health care services (using mHealth services). The population will be managers from private health care facilities including pharmacies (both retails and service) and hospitals. For the full scale study, a model will be used that combines results from research as reviewed in this paper. The following section describes the model and the basis of elements used.

5.1 Model

5.1.1 Elements for TAM

In order to measure the technology acceptance of managers, the following elements will be used in the model:

- Behavioural intention
- Perceived usefulness
- Attitude
- Institution Size

These first three elements were chosen because they directly work upon the behavioural intention, which in turn works on the actual use. Perceived ease of use will not be included, as it is expected to be high for cell phones, regardless of behavioural intention. The size of the facility was included, seeing that larger hospitals were found to show a greater behavioural intention (see 4.3.3).

5.1.2 Measuring context

In order to measure the context behind responses to technology acceptance, a model regarding the business's technology adoption will be included. An extensive review of models used in determining technology adoption at firm level was conducted by Oliveira and Martins [23]. One model, also by Oliveira and Martins [24], investigated e-business adoption. This model was tested extensively and concluded that the following factors influence a business's adoption of e-business:

- Perceived benefits and obstacles of e-business
- Technology readiness
- Competitive pressure
- Trading partner collaboration

Including these factors in the survey, together with factors from technology acceptance, will give a wide picture of the acceptance of the private health care sector for cell phone based health care services. The proposed model is shown in Figure 7.

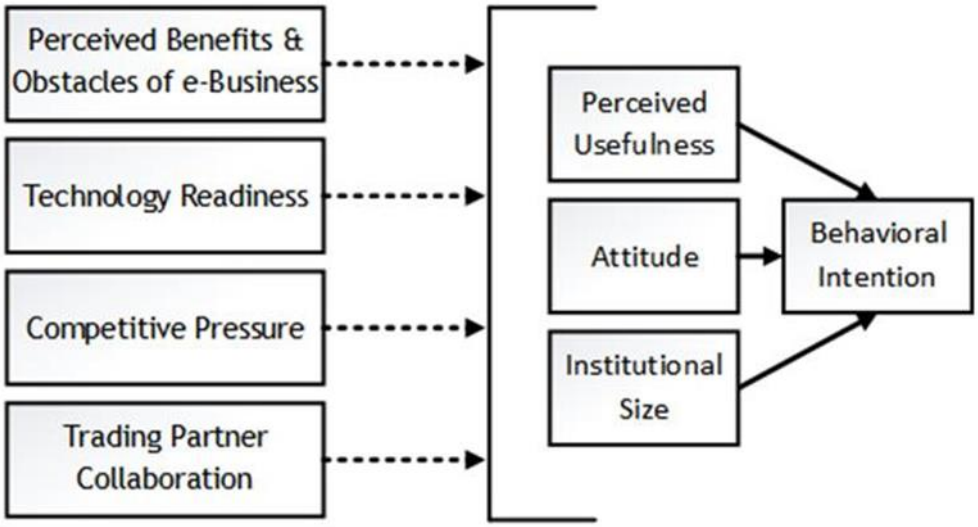

Figure 7: Proposed acceptance model for cell phone based health care

5.2 Expected results

By applying the above model, empirical data concerning the market for using cell phones in primary health care of South Africa can be determined. This information could be used to develop systems to improve health services and information delivery.

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