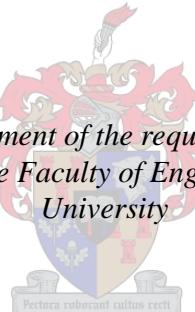


An Information Management System to Support Telemedicine Projects in South Africa

by
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*Thesis presented in fulfilment of the requirements for the degree of
Master of Science in the Faculty of Engineering at Stellenbosch
University*



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December 2012

Declaration

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Abstract

Telemedicine is a rapidly developing field in the medical sector that utilises modern day technology to provide improved health services to rural and remote areas. Telemedicine can also provide specialist support and remote consultation to facilities where there is a lack of resources. In South Africa, where a large percentage of the population live in rural and remote areas, telemedicine has the potential to alleviate the burden on national health resources, whilst improving the quality of healthcare.

Various telemedicine projects have been piloted in South Africa from its inception in 1998, with the primary objective being to address the inequalities of healthcare delivery in South Africa. Most of these projects did not get past their initial pilot phase. It is often difficult to determine the factors that contribute to a telemedicine project's success or demise, due to the unavailability of documentation for projects.

The purpose of this research project is to contribute towards sustained implementation of telemedicine projects, by assisting the Medical Research Council (MRC) in their current efforts. This has been done through the development of an information management system which can record and store relevant information regarding telemedicine projects in South Africa. The system allows users to document telemedicine projects, whilst also giving them access to technical- and descriptive information.

A total of 102 projects from the international academic domain were used to perform a meta-study, in order to determine the nature of telemedicine projects. Articles documenting various telemedicine projects were selected from the *Journal of Telemedicine and Telecare*. The telemedicine process data was then extracted and uploaded from these articles to the first version of the information system developed in this thesis. The meta-study was also used as the first phase of verification for the information system being developed.

Changes were made to the information system after the meta-study was completed. These changes included alterations to the database and the interface of the information system. Additional tables were added to the database of the information system, to store the data required by the MRC, in order to document telemedicine projects in South Africa.

The verification of the information system consisted of two testing phases. The first testing phase, the alpha test, was performed as part of the meta-study. The second testing phase was

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conducted after changes were incorporated into the information system, as necessitated by the alpha test and meta-study. In this phase of testing users could access the information system via the Internet.

The information system was validated in two phases. Firstly it was shown that the information system met the objectives set out for this project. Secondly it was shown that the information system has the capacity to assist in planning, development, implementation, and research through retrospectively examining two telemedicine projects in which Dr. Sam Surka (senior scientist and clinical manager at the MRC) was involved.

Outcomes of the project indicated that the information system is a useful tool for identifying similar telemedicine projects, and for assisting stakeholders in telemedicine projects.

Finally the research process was reflected upon to identify future work in terms of collecting telemedicine process data, as well as the assistance of telemedicine research within the South African context.

Opsomming

Telemedisyne is 'n vinnig ontwikkelende veld in die mediese sektor wat gebruik maak van moderne tegnologie om verbeterde gesondheidsdienste te verskaf aan landelike en afgeleë gebiede. Telemedisyne kan ook spesialis-ondersteuning en afstandsraadgewing bied aan fasiliteite waar daar 'n gebrek aan hulpbronne is. In Suid-Afrika, waar 'n groot persentasie van die bevolking in landelike en afgeleë gebiede woon, het telemedisyne die potensiaal om die las te verlig op nasionale gesondheid hulpbronne, asook die gehalte van gesondheidsorg te verbeter.

Verskeie telemedisyne projekte is in Suid-Afrika geloods vanaf 1998, met die primêre doel om die ongelykhede van gesondheidsorg in Suid-Afrika aan te spreek. Meeste van hierdie projekte het egter nie voortbestaan na hul aanvanklike proeffase nie. Dit is dikwels moeilik om die bydraende faktore te bepaal wat 'n telemedisyne projek se sukses of ondergang veroorsaak, as gevolg van die onbeskikbaarheid van dokumentasie vir die projekte.

Die doel van hierdie navorsingsprojek is om 'n bydrae te lewer tot die volhoubare implementering van telemedisyne projekte deur hulp te verleen aan die Mediese Navorsingsraad (MNR) se huidige ondernemings. Dit is gedoen deur 'n inligtingstelsel te ontwikkel wat relevante inligting opneem en stoor ten opsigte van telemedisyne projekte in Suid-Afrika. Die stelsel laat gebruikers toe om telemedisyne projekte te dokumenteer, asook toegang te bekom tot tegniese en beskrywende inligting.

'n Totaal van 102 projekte van die internasionale akademiese omgewing is gebruik om 'n meta-studie uit te voer ten einde die aard van telemedisyne projekte te bepaal. Artikels wat verskeie telemedisyne projekte dokumenteer is gekies uit die "*Journal of Telemedicine and Telecare*". Die telemedisyne proses data is vanuit hierdie artikels onttrek en opgelaaai na die eerste weergawe van die inligtingstelsel wat in hierdie tesis ontwikkel is. Die meta-studie is ook gebruik as die eerste fase van verifikasie vir die inligting stelsel wat ontwikkel word.

Veranderinge was aangebring aan die inligtingstelsel na die meta-studie voltooi was. Hierdie veranderinge sluit in die uitbreiding van die databasis en die koppelvlak van die inligtingstelsel. Addisionele tabelle is bygevoeg tot die databasis van die inligtingstelsel om die addisionele data te stoor soos vereis deur die Mediese Navorsingsraad (MNR), ten einde die telemedisyne projekte in Suid-Afrika te dokumenteer.

Opsomming

Die verifikasie van die inligtingstelsel bestaan uit twee toets fases. Die eerste toetsfase, die alfa toets, was uitgevoer as deel van die meta-studie. Die tweede toetsfase was uitgevoer na veranderinge aan die inligtingstelsel gemaak is, soos genoedsaak deur die alfa toets en meta-studie. In hierdie toetsfase kon gebruikers toegang tot die inligtingstelsel kry deur die Internet.

Die inligtingstelsel was bekragtig in twee fases. Eerstens, dit is aangetoon dat die inligtingstelsel die doelwitte bereik het, soos uiteengesit vir hierdie projek. Tweedens was aangetoon dat die inligtingstelsel die vermoë het om te help met die beplanning, ontwikkeling, implementering, en navorsing deur twee telemedisyne projekte te ondersoek waarin Dr. Sam Surka (senior wetenskaplike en kliniese bestuurder by die MNR) betrokke was.

Uitkomste van die projek het aangedui dat die inligtingstelsel 'n nuttige hulpmiddel is vir die identifisering van soortgelyke telemedisyne projekte, terwyl dit ook belanghebbendes van telemedisyne projekte ondersteun.

Ten slotte was daar besin oor die navorsingsproses om toekomstige werk te identifiseer in terme van die versameling van telemedisyne proses data, asook die ondersteuning van telemedisyne navorsing binne die Suid-Afrikaanse konteks.

Acknowledgements

I would like to take this opportunity to express my sincere gratitude to the following people who have made this thesis possible:

- My supervisor, Mrs. Liezl van Dyk, for her excellent guidance, patience with my ever-changing ideas, and the freedom she gave me to pursue the topic that I love.
- My family and friends: Thank you for all your love, support and understanding. You kept me going through the difficult times. Thank you for believing in me.
- Mrs. Jill Fortuin, director of Telemedicine and m-Health at the Medical Research Council, for her input and advice during the development and testing of the information system.
- Dr. Sam Surka, senior scientist and clinical manager at the Medical Research Council, for taking the time to assist me with the validation process.
- Mr. Ashley Bess, project and research coordinator at the Medical Research Council, for providing met with information pertaining to telemedicine projects in South Africa, necessary during the verification process.

Lastly, to my Heavenly Father for the talents, energy and enthusiasm He has given me to participate in this project. Without His blessings, I could not have completed this project.

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List of Abbreviations

AIDS	Acquired Immune Deficiency Syndrome
C#	C Sharp
CSS	Cascading Style Sheet
DSS	Decision Support System
e-Health	Electronic Health
EIS	Executive Information System
FTP	File Transfer Protocol
HTML	Hypertext Mark-up Language
ICT	Information and Communication Technologies
JSP	Java Server Pages
m-Health	Mobile Health
MIS	Management Information System
MRC	Medical Research Council of South Africa
PHP	Hypertext Pre-processor
SDLC	System Development Life Cycle
SMTP	Simple Mail Transfer Protocol
TCP	Transmission Control Protocol
TPS	Transactional Processing System
URL	Uniform Resource Locator
VB	Visual Basic
XML	Extensible Mark-up Language

1. Introduction

In July 1998, the South African Department of Health convened a National Telemedicine task team to co-ordinate the introduction of telemedicine into the delivery of health services in South Africa. The objective of the South African Telemedicine System is to deliver healthcare services that are of a high quality and are cost-effective to South African communities, particularly women and children in rural areas [1].

Many South Africans have experiences, and still experience inequalities, in the healthcare sector [2]. One of the major challenges that need to be addressed is the accessibility and availability of healthcare and specialised medical services in rural and remote areas in South Africa.

With the Government of South Africa searching for a solution in addressing the inequalities of healthcare delivery, telemedicine has emerged as a possible solution in providing healthcare to remote and rural areas. Telemedicine also has the ability to provide specialist support to medical staff over a distance.

It was initially expected that telemedicine would provide an answer to the ever growing healthcare needs of the South African population. However, 14 years after the initial implementation, telemedicine has not proved to be a sustainable solution for providing healthcare services to all South Africans. Many telemedicine projects were launched in this period, however, many have failed and the expected outcomes were never realised. The problem is not restricted to South Africa; many countries in sub-Saharan Africa have struggled to integrate telemedicine into its routine medical practices [3]. Factors contributing to the problem include a lack of infrastructure, shortage of health professionals and the cost of bandwidth.

The South African Department of Health has reported that, over the last decade, most of the 86 telemedicine projects, initiated since the early 2000s, have failed and are no longer operational since the beginning of 2010 [4]. However, preliminary studies have suggested that some telemedicine services in the Eastern Cape have, in fact, been successful. The current study aims to find out whether the services have indeed succeeded and if so, what the reasons for the success were. The application of possible advances made could help in future telemedicine planning. No evaluation of any telemedicine project has as yet been undertaken, so the reasons for the failure of certain telemedicine projects have yet to be established.

A proposition of this study is that it is possible to evaluate telemedicine projects by utilising engineering skills and techniques. Health systems engineering is an academic discipline in which researchers and practitioners treat the healthcare industry as complex systems, and further identify and apply engineering applications in such healthcare systems [5]. Many engineering applications, such as optimisation, decision making, human factors engineering, quality engineering, information technology and communication, and knowledge discovery are currently utilised at various levels of health systems.

The systems engineering approach adopted by industrial engineers have the potential to address many of the challenges faced by the healthcare delivery system. It is possible that a collaboration between disciplines will lead to solutions that will not only result in incremental changes to the healthcare delivery system (e.g. decreased waiting times and more efficient scheduling), but also breakthrough adjustments which could lead to an ideal healthcare delivery system [6].

1.1 Background to the Problem

South Africa has been involved with the implementation of telemedicine since 1998 and has put into practice various telemedicine projects throughout the country. South Africa is now at a stage where it has the potential to build on its experience in e-Health and telemedicine and to make successful inroads into this field. There is political motivation for this to happen and basic enabling policy is already in place for the use of ICT (Information and Communication Technologies) in healthcare [7].

To effectively develop support tools to assist in the implementation and maintenance of telemedicine systems, sufficient data is required. However, as was mentioned above, there is a lack of data acquisition and analysis. To address this issue, a database is required to obtain and store relevant information pertaining to telemedicine projects in South Africa. This will allow academics, researchers and private institutions to develop effective and necessary tools, applications and frameworks to support the integration of telemedicine in healthcare.

The project will also contribute towards the Medical Research Council of South Africa's agenda of collating a comprehensive database of m-Health initiatives in South Africa, assist in the assessment stages of development and help to identify possible lighthouse projects for roll out.

1.2 Purpose of the Project

The purpose of this research project is to contribute towards the sustained implementation of telemedicine projects through the development of an information system, which will record and store relevant information pertaining to telemedicine projects in South Africa. The system will allow users to document telemedicine projects, as well as supplying access to technical process information on similar projects they are implementing or are planning to implement.

1.2.1 Proposition

1. Despite the lack of evidence, successful telemedicine projects in South Africa do exist.
2. An analysis of these projects will provide information that is able to increase the success rate of telemedicine projects.

1.2.2 Methodology

The Systems Development Life Cycle (SDLC) is a conceptual model used in project management that describes the stages involved in the development of an information system. It includes all the stages of the project, from the initial feasibility study through to the maintenance of the completed system [8]. The Systems Development Life Cycle is shown in Figure 1-1.

The development method is a phased approach to information system analysis and design. Although analysts disagree on the exact number of phases involved in the cycle, the organised approach is generally applauded. Although the figure suggests that each phase happens discretely, the steps are never completed in isolation. Several activities can happen simultaneously and some activities can be repeated multiple times [9].

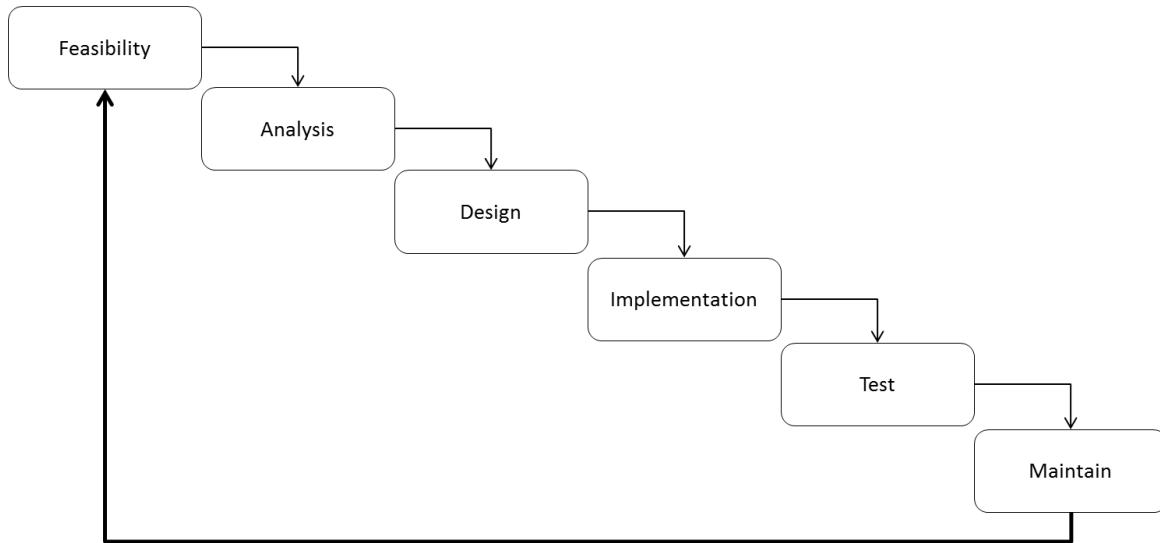


Figure 1-1: The System Development Life Cycle

For the purpose of this study, a similar approach to that of the System Development Life Cycle will be used. The development approach that will be used for this study is shown in Figure 1-2. Due to there being very little documented data pertaining to telemedicine in South Africa, an initial study needed to be done. The initial study will lead to a better understanding of telemedicine, its capabilities as well as the challenges it faces. The initial study does not require an analysis, hence its omission from the derived development approach. However, an analysis of the data captured by the information system will be performed and is included in the development approach.

The rest of the development approach is similar to that of the original SDLC. The scope of the project proposed in this study is indicated by the shaded area in Figure 1-2. The operation and maintenance of the information system, once completed, will be the responsibility of the Medical Research Council. They are, for the purpose of this project, the client. The testing and evaluation will be used to verify and validate the information system. Issues and problems identified during the testing and evaluation process will be addressed, since it is within the scope of the project, indicated by the feedback loop to the design step.

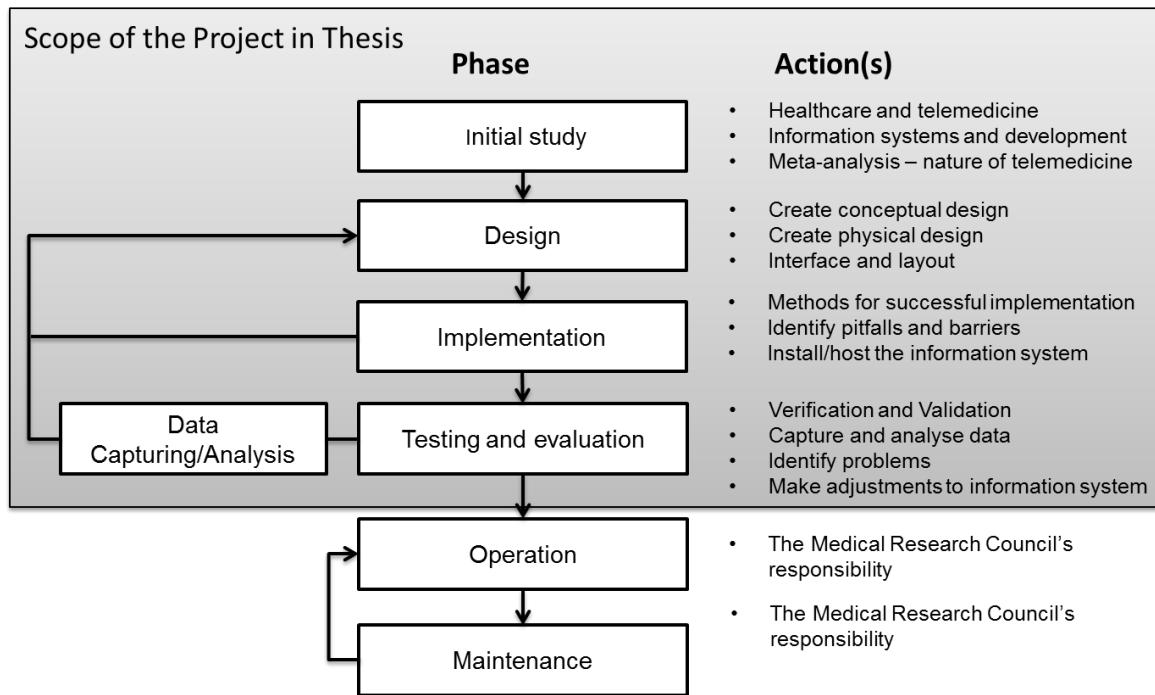


Figure 1-2: Development approach derived from the SDLC

1.2.3 Objectives of the Study

Objectives of the project are:

1. To help identify best practices for telemedicine implementation within a specific context. Finding past projects of a similar nature and learning from them, will greatly contribute in identifying best practice methods.
2. To provide the Medical Research Council (MRC) with an information management tool (collect- and retrieve) for telemedicine research in South Africa. The tool must also serve as a platform for strengthening the interaction between the different disciplines involved in telemedicine. The recent shift to online platforms will extend the reach of collaboration between different disciplines, and will allow a global exchange of knowledge.
3. To assist the MRC in achieving a key deliverable, thus collating a comprehensive database for m-Health initiatives in South Africa, as stipulated by the National Department of Health. Although the focus of the project is on telemedicine, m-Health is included in the definition of telemedicine (according to the South African Department of Health's definition of m-Health). The objective of documenting m-Health and

telemedicine projects in an integrated fashion can therefore be accomplished with minimal effort.

4. To provide an “open source” web-based resource for telemedicine. The “open source” in this instance involves an environment where like-minded individuals can contribute to the feasibility of telemedicine by providing information, knowledge, support and personal skills without the continuous influence of advertisements and money.

1.2.4 Stakeholders Identified

The project aims to support the following stakeholders within the telemedicine community:

- The South African Medical Research Council – documenting m-Health projects directly impacts one of the objectives of the telemedicine department at the Medical Research Council.
- Researchers / Academics – technical data about telemedicine projects can be used to develop frameworks and tools to support telemedicine projects.
- Medical Practitioners – the support network established by the information system can be used to initiate interaction between medical practitioners and other stakeholders within the scope of telemedicine application in South Africa. This will give researchers, developers and technicians a better idea of what is needed in practice.
- Medical Support Staff – applications developed to simplify the tasks of medical staff can be shared on the network.

1.3 Chapter Overview of the Study

The layout of the project is illustrated in Figure 1-3. The project can be divided into two phases. The first phase is the initial study, consisting mostly of literature. It also includes a meta-study concerning the nature of telemedicine projects. The second phase is the development approach and discusses the design and development of the information system. It also includes the verification and validation of the information system. The project is ended with concluding remarks and a discussion regarding future works relating to the information system. Sections 1.3.1 to 1.3.3 provide a more detailed description pertaining to the specific phase of the project.

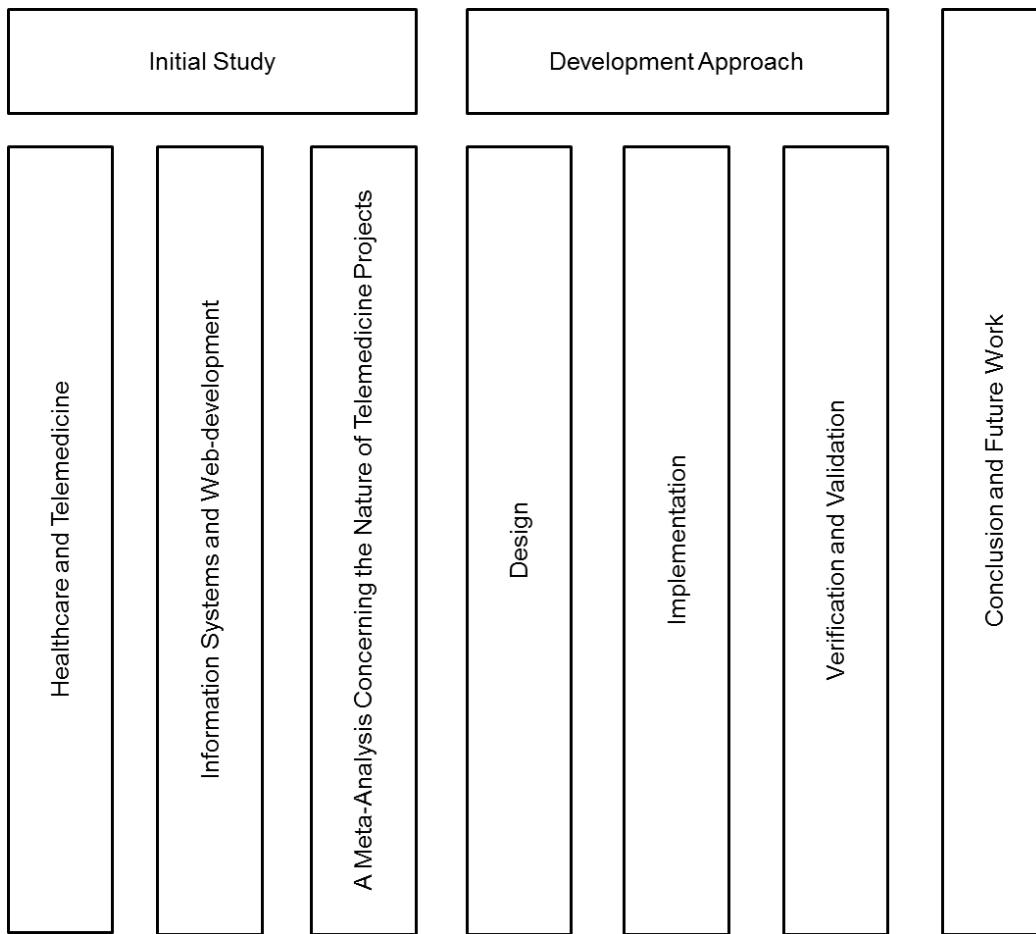


Figure 1-3: Chapter layout of the project

1.3.1 Initial Study

Chapter 2 performs a literature review concerning healthcare and telemedicine. This includes a discussion about healthcare in South Africa, its current status and some shortcomings of health services. This serves as an introduction to telemedicine and its function in healthcare. The rest of Chapter 2 focuses on telemedicine, including a general review as well as a review within the context of South Africa. Various telemedicine topics are discussed, including the applications of telemedicine, advantages of telemedicine, shortcomings and pitfalls of telemedicine. Some examples of telemedicine projects in South Africa are also given.

Chapter 3 provides an overview of information systems and web-development methods necessary to develop the information system proposed in this project. The different types of information systems and their applications are described. Hardware and software components required to develop an information system are also evaluated and discussed in this chapter.

Chapter 4 discusses the meta-study performed concerning the nature of telemedicine projects. This analysis is performed using literature pertaining to telemedicine projects. Information about the telemedicine process is documented using a preliminary information system.

1.3.2 Development Approach

Chapters 5 and 6 document the development and implementation phase of the project. In Chapter 5, the design of the information system is discussed. This includes the development of the database and the interface. Literature pertaining to the software and hardware requirements of the information system is also included in this chapter.

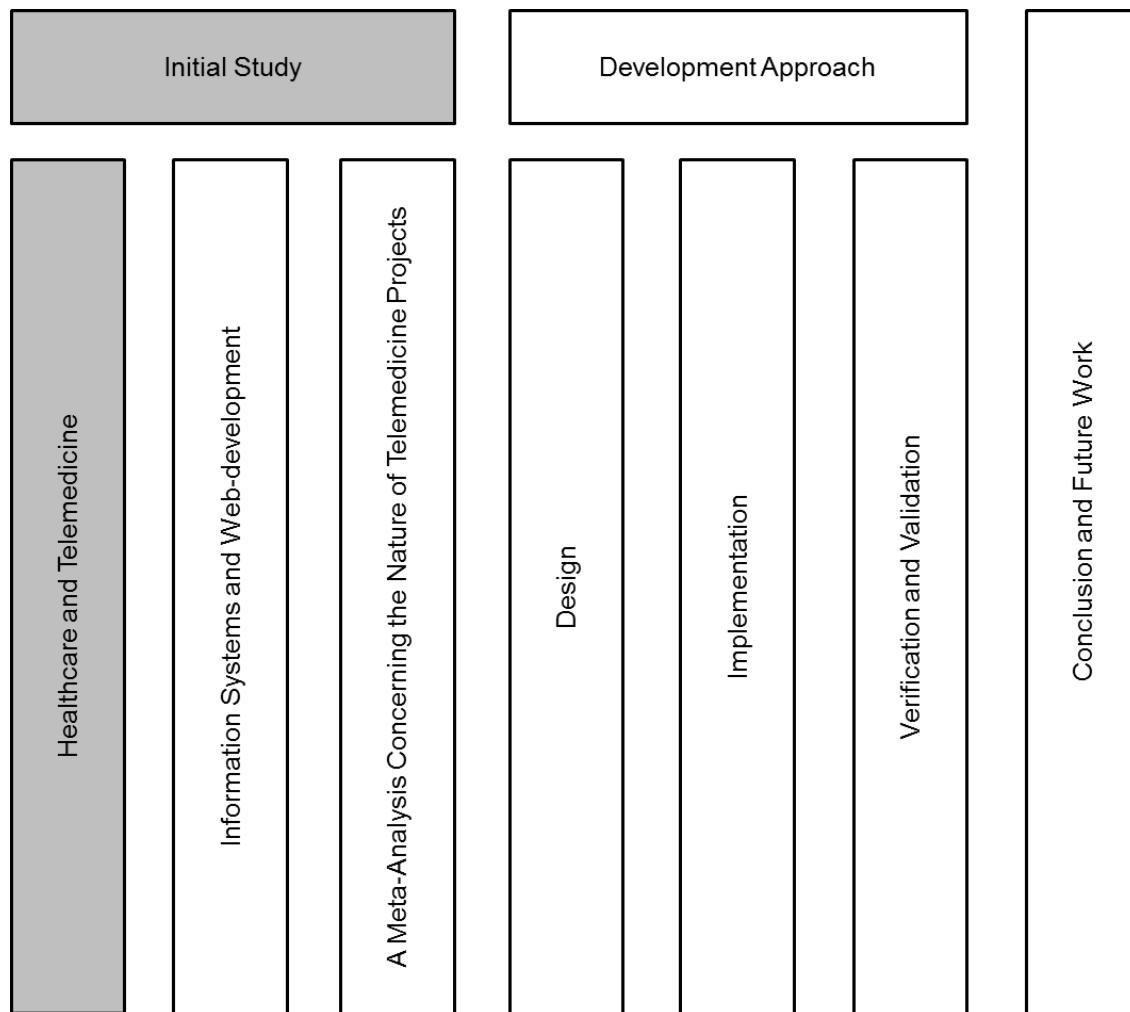
Chapter 7 discusses the testing and evaluation of the information system. The information system is verified and validated in two stages, these are the alpha test, performed during the meta-study, and the beta test, performed after all the design requirements are incorporated into the information system.

1.3.3 Conclusion and Future Work

In Chapter 8, the initial study, the development approach and the analysis of the data, are summarised. The most important results obtained in the project are discussed. Conclusions are drawn and the project's objectives with regards to the final system are discussed. Future works that may emanate from this project are also proposed.

2. Healthcare and Telemedicine

To understand why there is a need for telemedicine applications within the healthcare sector of South Africa, it is important to appreciate the South African healthcare system. The next section gives an introduction to healthcare and its status in South Africa. This discussion is followed by an in depth look at telemedicine, both in general, as well as specifically in South Africa. This chapter is the first of two literature review chapters which comprise the initial study of the System Development Life Cycle (SDLC).



2.1 Healthcare

Access to quality healthcare is a basic human right. However, there are many instances where there is a clear distinction between the standard of care that people receive based on the socio economic group to which they belong. Bridging the gap is not always merely a matter of increased financial aid to those in need; a lack of infrastructure, resources, as well as the rural and remote nature of the locations make it difficult to provide the same quality of care. It is thus essential that people from different specialities, across multiple disciplines, work together to find feasible solutions to provide everyone with access to quality healthcare.

2.1.1 Status of Healthcare in South Africa

Until recently, South Africa had more HIV positive people than any other nation. Data from 2000 show HIV/AIDS to be the greatest cause of death (30%), followed by cardiovascular disease (17%), intentional and unintentional injuries (12%), non-HIV related infectious and parasitic disease (10%), and malignant neoplasms (7.5%). The incidence of tuberculosis is 1.0% and is on the rise [7]. Figure 2-1 shows the prevalence of AIDS amongst South Africans, who are older than 2 years, from 2002-2008. From the graph, it is evident that no significant reduction in HIV cases has been made, except for children under the age of 14. This perhaps explains why many telemedicine applications in South Africa are focused on HIV/AIDS prevention and treatment.

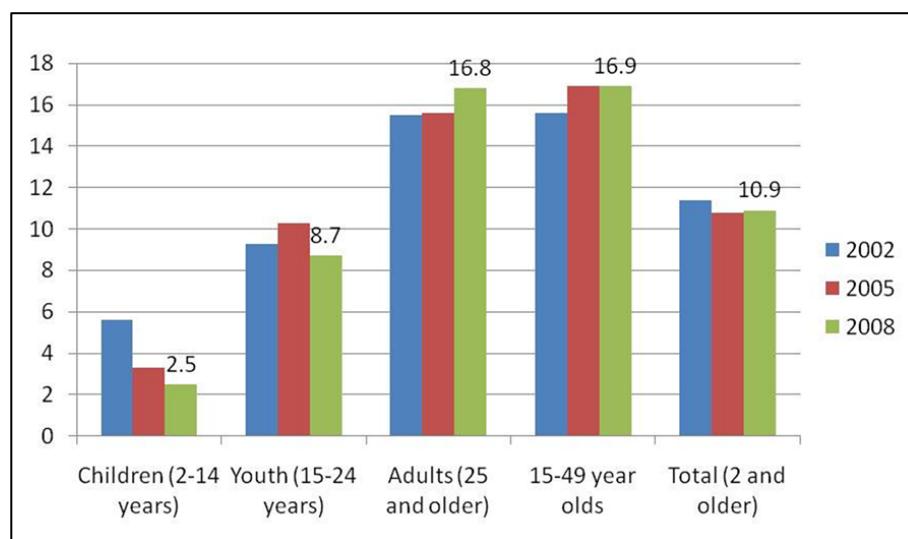


Figure 2-1: Estimated HIV prevalence amongst South Africans aged 2 years and older, 2002-2008 [10]

The South African healthcare system consists of a large public sector and a smaller, but fast growing, private sector. In most instances, the public sector is under-staffed and does not always possess the necessary resources to deliver the quality of care required. The private sector caters for the middle- and high income groups, with most of its members belonging to private medical aid schemes.

Although 40% of all healthcare expenditure is provided by the state, the public healthcare sector is responsible for service delivery to approximately 80% of the population. Despite the fact that most of the population is treated in the public sector, most of the resources are concentrated in the private health sector [11], which has led to immense pressure to provide adequate healthcare.

The cost of medication varies significantly between the private and the public healthcare sector. In 2000, approximately R8.25 billion was spent on drugs, of which only 24% was paid for by the government. On average, R59.36 was spent on medication, per person, in the public sector while R800.29 was spent, per person, in the private sector [11].

In South Africa, the number of private hospitals and clinics continue to grow. Less than five years ago there were 161 private hospitals, mostly located in urban areas, at present there are over 200. The mining industry has had a big influence in South Africa and has provided more than 60 hospitals and clinics around the country [12].

Most of the healthcare professionals in South Africa work in private hospitals. Private hospitals have also started to take over many of the tertiary and specialist healthcare services, due to the public sector's shift in emphasis from acute to primary healthcare in recent years [13].

Approximately 11% of the government's total budget is allocated to public health, which is divided between the nine provinces. The methods involved in allocating the resources and determining the standard of care delivered, vary from one province to another. With the ever increasing expense involved in treating disease and the number of people belonging to the low-income sector of the wealth classification spectrum on the rise, cash-strapped provinces like the Eastern Cape, face greater health challenges than wealthier provinces like Gauteng and the Western Cape [11].

In recent years, telemedicine has been championed as a possible solution to combat the need for expensive medical resources and to combat the distance problem associated with health delivery services to rural areas in South Africa.

2.2 Telemedicine and the Definition of Telemedicine

Delivering healthcare (“-medicine”) over distance (“tele-”) is an age-old practice which was initially conducted via post [14]. Providing healthcare in absentia has had a long and successful history and recent advancements in communication technology has meant that telemedicine has evolved into what it is today.

Early uses of telemedicine included African villagers using smoke signals to warn people of serious diseases in the village. In the early part of the 1900s, people in remote regions of Australia implemented a system using two-way radio, powered by a bicycle-driven dynamo, to communicate with the Royal Flying Doctor Service of Australia [14].

Various definitions for telemedicine exist, some phrased in such a way that the concept becomes over complicated. A few of the definitions used by major contributors in the development and implementation of telemedicine are given below:

1. American Telemedicine Association’s definition:

“Telemedicine is the use of medical information exchanged from one site to another via electronic communications to improve patients’ health status [15].”

2. World Health Organization’s definition:

“Tele-medicine is the use of telecommunications to diagnose and treat disease and ill-health. Telematics for health is a WHO composite term for both tele-medicine and tele-health, or any health-related activities carried out over distance by means of information communication technologies [16].”

3. South African Department of Health’s definition:

The Department of Health has also stated that m-Health is inseparable from telemedicine and e-Health.

“Combined utilization of electronic communication and information technology to generate, transmit, store and retrieve digital data for clinical, educational and administrative purposes.”

Sood et al. [17] also provide a definition of telemedicine which encapsulates and addresses the issue of the uneven distribution of health resources, specifically related to South Africa’s public healthcare sector.

For the purposes of this study, telemedicine is considered to be a subset of telehealth, which uses communication networks for delivery of healthcare services. It also improves the availability of medical education from one geographical location to another, primarily to address challenges like uneven distribution and shortage of infrastructure and human resources [15].

2.3 Origins of Modern Telemedicine

Today telemedicine differs greatly from its humble origins in the Netherlands in the early 1900s, as does medicine and medical care in general. A major contributing factor to this change in telemedicine can be attributed to the shift in the application of telemedicine in mainstream healthcare practices [14].

The early pioneers of telemedicine were primarily guided by intuitive logic and reasoning. It was obvious to them that telemedicine would extend the reach of medical care and specialist support to patients in remote areas. The elimination of duplicate and unnecessary referrals also contributed to a growing interest in the application of telemedicine. In addition, the continued improvement in telecommunication technologies has further increased the capabilities and impact of telemedicine. Telecommunication has the potential to provide clinicians and patients in remote locations, ready access to specialist medical support, with a minimum of effort [14].

Phase I

The first phase of telemedicine ended in the 1970s because of a lack of evidence in support of the use of telemedicine. Slow advances in telecommunication technologies stifled its growth, which eventually led to the downfall of telemedicine as a viable solution to the ever increasing demand for quality healthcare. In addition, external funding for telemedicine research and projects dried up and the use of telemedicine became practically non-existent [14].

Phase II: Resurgence

The second phase of telemedicine, also known as the revival of telemedicine, took place in the 1980s. This was due to major improvements in technology with regards to capability, quality, reliability, versatility, size, and ease of use. A substantial decline in the price of transmission, storage, processing, and retrieval of information, as well as several basic components and peripheral devices, also contributed to this resurgence. Another contributing factor was that there were still major intransigent problems in healthcare delivery and telemedicine was perceived as a possible solution.

The type of telemedicine system that was used was directly related to the dominant technology of the era. The 1970s and early 1980s were dominated by telecommunication technology thus, the telemedicine system of choice was telephone based. This can arguably be viewed as the most basic form of modern telemedicine. However, in the 1990s, telemedicine systems used images and other digital mediums to diagnose and evaluate patients over a distance. Since the mid-1990s to date, the Internet, in conjunction with various other medical devices, has been the dominant platform for the development and implementation of telemedicine systems. M-Health (mobile health technologies) and Health 2.0 (use of blogs, podcasts, tagging, wikis, and others) are some of the more recent technologies used in telemedicine systems.

2.4 Telemedicine in South Africa

The initial implementation of telemedicine in South Africa can best be described as unsuccessful. Incorrect administration of projects and funds led to its lack of success and negative image. However, due to recent efforts on the part of the government, academic institutions as well as private vendors, telemedicine is resurfacing as a viable solution in healthcare delivery. There is a keen focus on increasing life expectancy, improving the quality of healthcare, reducing costs and addressing the inequalities of sub-standard healthcare in rural areas [4].

2.4.1 History of Telemedicine in South Africa

In 1995, the National Health Information Systems Committee of South Africa was established. The newly appointed committee was requested to create a comprehensive national health information system for South Africa [3]. The first phase of telemedicine implementation started in 1998 and was guided by the National Strategy for Telemedicine. The objectives of the strategy focused on providing high-quality, cost-effective healthcare and education; improved

recruitment and retention of health professionals; the delivering of healthcare over distance, and ensuring that specialist healthcare was more accessible than in the past [18].

In 1999, the National Department of Health (NDoH) initiated 28 pilot telemedicine projects in six different provinces. The main focus of the projects was on teleradiology, together with tele-ultrasound, telepathology and tele-ophthalmology. The establishment of a national telemedicine research centre was also part of this first phase of telemedicine in South Africa [19].

The second phase of telemedicine application in South Africa happened during the period April 2001 to March 2002. It involved the development of an effective telemedicine network, connecting 75 sites, and divided into various provincial networks for management purposes [19].

The third phase of telemedicine application lasted from April 2002 until March 2004. This phase involved the establishment of additional sites, as many as were required to provide affordable healthcare services, in the hopes of meeting the needs of patients in the rural areas [19].

Since the third phase of telemedicine application in South Africa, much has happened to promote and develop the application of telemedicine in South Africa. Collaboration between the South African Government, specifically the Telemedicine and m-Health Department at the Medical Research Council of South Africa [7] and such academic institutions, as Stellenbosch University, KwaZulu-Natal University, and the University of Cape Town, has begun. Moreover, various non-government organisations, such as Cell-life and the Praekelt Foundation, have become involved in the development and application of telemedicine technologies. To add to the growing interest in telemedicine two conferences were held in 2010 and 2011 respectively, with the third conference scheduled for the third quarter of 2012 [20]. The interest that has been shown is evidence of the expansion telemedicine has experienced in South Africa since 2004.

2.4.2 Current Status of Telemedicine in South Africa

Public health informatics and telemedicine in South Africa are coordinated by the National Department of Health (NDoH). South Africa has one National Health Department, responsible for healthcare in South Africa, and nine Provincial Departments of Health. The Provincial Departments of Health are responsible for their respective health information systems and telemedicine projects. The National Health Information System Directorate in the NDoH is

responsible for policy and regulation of e-Health, as well as the coordination of the implementation of e-Health projects and programmes [7]. In addition to this, the private health sector in South Africa is involved in the implementation of telemedicine, especially with respect to teleradiology (the transmission of radiological patient images from one location to another for diagnostic purposes).

There are a number of non-government organisations (NGO) involved in telemedicine in South Africa. These include organisations such as Cell-Life and the Praekelt Foundation, both of which specialise in mobile service delivery. Most of these projects focus on creating awareness of a specific disease and reminding patients of their medical schedule.

A framework for the implementation of an electronic health record system in South Africa [21] has also been developed. It was awarded to a consortium of three vendors [7].

The main purpose of telemedicine and e-Health in South Africa is to support general healthcare services and to improve the quality of healthcare services provided to previously disadvantaged persons, especially those in the rural and remote regions of South Africa. This includes telemedicine- and e-Systems in:

- the delivery of healthcare;
- the surveillance of diseases and services;
- health emergencies and hazards;
- the management of healthcare institutions;
- access to repositories of knowledge, applications and literature; and
- the education of the public and formal education of health service professionals.

Telemedicine is seen as a possible tool to bridge the gap between the rich and the poor, between people living in rural and urban areas, and also to address the issue of unequal distribution of healthcare professionals [7].

One of South Africa's main issues in providing health information to the public is the language barrier. Due to the fact that South Africa has 11 official languages, the expense and effort required to provide information in all the languages is very high and time-consuming. Another difficulty is the fact that in some rural areas, literacy amongst the adults is below 50%, making the task of providing relevant and necessary information somewhat challenging. Collecting information from patients could also pose a problem.

By definition, telemedicine and e-Health require the use of information and communication technologies by healthcare workers to add, access, interpret and analyse information [7], although the lack of infrastructure in rural areas complicates this requirement. Many healthcare workers operating in South Africa have not been exposed to a culture of technology, and are thus ill-equipped to acquire data and analyse the findings.

2.4.3 Examples of Telemedicine Projects in South Africa

In South Africa, many telemedicine projects have been initiated; few, however, outlasted the pilot or trial stage. Some of these failed projects will be discussed briefly in this section.

In several provinces, particularly in the Free State, selected teleradiology projects were initiated at the following hospitals: Harrismith; Zastron; Senekal, and Universitas Academic hospital. In addition, an early link was established for telepathology in the Eastern Cape, with the service being driven by a professor who was based at Walter Sisulu University. Collaborative links were also forged with the University of Basel and the Armed Forces Institute of Pathology, Washington, USA [22].

In the Western Cape, two telemedicine projects were launched. One focused on tele-education and the other focused on telepsychology. The latter was an ambitious project, inaugurated by the then Minister of Health. The project served a region where the inhabitants suffered from alcoholism and violence formed part of their daily existence. The project supported nurses at the local clinic, who often had to deal with severely agitated patients. Over the weekends, these patients were confined to police cells until a local state doctor, rather than a psychiatrist, could see them.

The Department of Psychology at the University of the Western Cape, which is situated 450 kilometres away from that particular region, provided a consultation service, and also used related material for teaching purposes. The same link allowed access to tele-education for two groups of labour counsellors. The one group consisted of local professionals, teachers and social workers. and the other consisted of senior high school students, who acted as peer counsellors. The project ended prematurely when the equipment concerned was stolen [22].

In KwaZulu-Natal, a tele-ophthalmology service was set up. The service was provided at six different hospitals, and was administered by various specialists and clinicians, together with the University of KwaZulu-Natal. When the last audit was performed, it indicated that 282 cases had

been referred in 18 months. It also saved 82% of the patients an unnecessary transfer to the academic unit, situated 118 kilometres away [3].

In the Eastern- and Western Cape, a tele-nuclear medicine link, which depended on the aerial transmission of data on computer discs, was established. The service was supported by the appointment of a person who was able to interpret the findings of the relevant nuclear medicine studies at these remote sites. Another link between the Western Cape and Lusaka, Zambia failed because of a lack of sufficient funding for radiopharmaceutical supplies. However, most of the telemedicine ventures were unsuccessful mainly because relevant personnel received insufficient training; there was a lack of enthusiasm for the project from the personnel, who often regarded the introduction of telemedicine as an increase in their workload, because no additional posts were created at the time of implementation; there was a lack of local support for the project; and because of the inflexible nature of the equipment used during the early stages of implementation. When other telemedicine links were set up, which were accessible by means of computers, they were more successful [22].

2.5 The Medical Research Council of South Africa

The South African Medical Research Council (MRC) is a health research council which was established with a mandate to promote the improvement of the health and quality of life of South Africans through research, development and technology transfer. The MRC carries out its mandate by discovering solutions to health problems through scientific research conducted by qualified researchers. The MRC's strategic research areas include HIV/AIDS, malaria, tuberculosis, cancer, public health research, health promotion, African traditional medicines, nutrition and telemedicine [23].

The MRC also provides information at many different levels, including policy recommendations on various healthcare issues, to decision-makers in the government. The MRC's Innovation Centre is responsible for the management and commercialisation of the Intellectual Property emanating from the MRC's research. The Innovation Centre has uniquely qualified individuals with experience in technology transfer and intellectual property issues. The Innovation Centre formulated the MRC's intellectual property policy and implements this strategy in line with national policies and legislation [23].

The MRC is also dedicated to developing and implementing telemedicine technologies throughout South Africa. The Department of Telemedicine and m-Health, headed by Jill Fortuin at the MRC, is responsible for their own telemedicine portfolio. The MRC, in collaboration with Stellenbosch University, hosted its second successful telemedicine conference in South Africa in 2012. Delegates from all over the world attended, giving much needed support and recognition to the cause of telemedicine in South Africa.

The MRC plays a vital role in the successful application of telemedicine in South Africa, both by collaborating with the different stakeholders involved in the telemedicine project, as well as by providing funding to various institutions and individuals involved in telemedicine.

2.6 Types of Telemedicine

Telemedicine can be divided into three main categories: store-and-forward, remote monitoring and interactive services.

Store-and-forward telemedicine involves acquiring medical data and then transmitting this data to a doctor or medical specialist at a convenient time for assessment offline. This data includes medical images, bio signals or any patient information captured by a medical device or healthcare practitioner. The simultaneous presence of both parties is not a prerequisite. Dermatology, radiology, and pathology are common specialties implemented in this type of telemedicine. A properly structured medical record, preferably in an electronic format, should be a component of this transfer. A key difference between traditional patient-doctor face-to-face meetings and telemedicine encounters is the omission of an actual physical examination. The store-and-forward process requires the clinician to assess and diagnose the patient, based on the patient's history report and the audio/video information, instead of a physical examination [24].

Remote monitoring allows medical professionals to monitor a patient using information and communication devices. This type of telemedicine is also known as self-monitoring/testing. The primary use for this type of telemedicine is the management of chronic diseases or specific conditions, such as heart disease, diabetes mellitus, or asthma. Treatment in this way can be just as successful as those using traditional procedures. Moreover, these methods tend to provide greater patient satisfaction and be more cost effective than traditional methods [24].

Interactive telemedicine is a service which provides real-time interaction between the patient and the provider. This method includes phone conversations, online communications (usually a form of video conferencing) and home visits. A review of the patient's history, a physical or psychiatric evaluation and ophthalmology assessments are some of the activities that can be conducted in a similar way to those done in traditional face-to-face visits. A benefit of this form of telemedicine is that it tends to be more cost-effective, than the usual consultation methods [24].

It is important to know the different types of telemedicine systems and their applications. By differentiating between the different types of telemedicine systems, telemedicine projects can be categorised according to the type of project. In addition, categorising the projects in such a manner will help to identify correlations between projects of the same type.

2.7 Applications of Telemedicine

Telemedicine has many applications and can be used in various sectors of healthcare, to provide quality care where it would otherwise not have been possible. Telemedicine is often used in cases where the traditional method of providing healthcare would have been too expensive, the location too remote and inaccessible or where the situation is dangerous. Some of the main applications of telemedicine will be discussed in the following sections.

2.7.1 Rural Health

One of the greatest challenges to rural healthcare is to provide the correct medical care when it is needed. Here, distance plays a major role and the lack of infrastructure adds to the difficulties experienced in this area of healthcare. The fact that rural healthcare facilities are unable to attract, afford or retain speciality providers is an additional concern [25].

Telemedicine helps to overcome the distance barrier, as well as allow access to specialist support, regardless of the location. This can be done by using video conferencing equipment, store-and-forward solutions, or a combination of the two. Typically, telecommunication technologies are used to connect patients and practitioners situated in a rural location with specialists in a distant hospital or medical centre [26]. This reduces or eliminates the need for travel for either the patient or the specialist. This method can also reduce the number of unnecessary referrals.

Additionally, telemedicine can be used to train and retain clinicians due to the constant training support from the specialist by means of remote participation.

2.7.2 Developing Countries

Telemedicine allows the rapid deployment of healthcare services to a developing population through relatively low cost clinics. By eliminating the need for a large number of sophisticated facilities, telemedicine allows basic clinics to share expertise with a centralised or decentralised support network [25].

In developing countries, specialists and skilled clinicians are often in short supply, providing an excellent rationale for the use of telemedicine which allows for an optimised and more efficient use of resources. Since specialists are only called in when they are needed and travelling time and costs are avoided, patients are afforded access to specialist healthcare at a fraction of the normal cost, providing an opportunity for quality healthcare in developing countries.

2.7.3 Corrections

The quality of healthcare delivery in correctional facilities has always been a human rights concern. As recently as the 1970s, correctional healthcare was primitive, with inmates resorting to self-help or helping each other. Today, in many nations, healthcare provided to prisoners has greatly improved rivalling, in some instances, healthcare services to the general public [27].

Telemedicine allows prison facilities to deliver high quality care without the cost and dangers involved when treating prisoners. This form of healthcare has proven effective for clinical as well as mental health. The United States of America has implemented telemedicine in various prisons and it has been found to be effective, safe and cheaper than the traditional method of face-to-face treatment [25].

2.7.4 Schools

The application of telemedicine in schools allows the school nurse access to expert medical support when it is needed. The nurse has to respond to a variety of needs, yet he/she is an isolated provider. In rural communities, where specialist resources are scarce, the school nurse may be the only healthcare provider. If the nurse cannot treat the issue, the student must be

referred to a specialist, who in most cases, is situated far away. The use of telemedicine can avoid these costs and also minimise the number of referrals to specialists [25].

An example of a telemedicine application in schools is the Telekid Care™ project in urban Kansas City, Kansas in the United States. Telemedicine units were allocated to school nurses and then linked to physicians at the University of Kansas Medical Centre (KUMC). From the four elementary schools participating in the project, 187 consultations were conducted. The average time that elapsed between the request for a consultation and the confirmation of an appointment was 23 minutes. This project demonstrated that telemedicine is able to offer immediate healthcare to children in need [28].

2.7.5 Mobile Health

Mobile healthcare units allow access to specialist support, regardless of the location. This is ideal for telemedicine implementation in developing countries where the infrastructure in rural areas is underdeveloped and wireless communication is available. Mobile healthcare can serve the community; challenging cases can be referred to a specialist who in turn can provide diagnostic support and treatment advice to ensure patients in remote and rural areas receive appropriate medical care [25].

Young Africa Live (YAL) is a mobile platform developed to educate young people in South Africa about HIV/AIDS. The project was initiated by the Praekelt Foundation and aims to educate young people about HIV/AIDS in an entertainment-orientated, fun and interactive manner. The project was launched on the 1st of December 2009 and is currently on-going [29].

2.7.6 Disaster Relief

Like rural and mobile health, disaster relief also benefits from the implementation of telemedicine. Telemedicine allows fast healthcare delivery after a disaster. Telemedicine facilitates the correct medical personnel to be present at the scene, as well as access to advanced expertise and support when and where it is most needed [25].

The National Aeronautics and Space Administration (NASA) used information technology following the 1985 earthquake in Mexico City to furnish disaster aid. Advanced satellite technology was used to provide voice communication support to the international rescue and relief efforts. The link was crucial because all forms of land-based communication were

disrupted because of the earthquake. Furthermore, this communication link provided the necessary consultation in the areas of neurology, orthopaedics, psychiatry, infectious diseases, and general surgery [30].

2.7.7 Shipping and Transportation

The use of telemedicine in shipping and transportation extends to the crew, guests, and passengers at sea as well as in the air. Access to advanced medical expertise, advice and treatment, is possible through the use of telemedicine, regardless of location. High costs and unscheduled diversions can also be avoided [25].

The ‘Alwyn North’ oil platform in the North Sea, installed satellite communication and videoconferencing equipment, with medical advice being provided by the call centre in Milan. Over the nine month trial period, remote consultations were performed approximately twice a week and the onshore physicians were satisfied with the quality of the images and information provided in each case. This method of providing specialist medical support via videoconferencing reduced unnecessary and/or untimely patient evacuation to hospitals [31].

2.7.8 Industrial Health

Mines, drilling platforms and industrial campuses depend on the health of their employees to operate. The work environment of these employees is often dangerous and the healthcare needs are unpredictable. In these situations, telemedicine can provide quick and effective medical support whilst avoiding the high cost associated with evacuation. It also ensures that workers receive appropriate medical treatment as soon as possible [25].

A telemedicine link between a mining town in Western Australia and specialists in Perth, approximately 1800 kilometres away, was established using standard videoconferencing equipment. During a 2 year period, 90 tele-consultations were carried out with the most common injuries being eye-related problems. In more than 75% of the tele-consultations, a patient transfer to Perth was avoided [32].

2.8 Benefits of Telemedicine

Telemedicine is most beneficial to people and communities living in remote and rural regions where access to traditional medical care is difficult. The application of telemedicine has

integrated itself into virtually all medical domains, including the vital areas of medical care required by people living in remote regions [33].

Each telemedicine project will provide its own unique benefits. The potential benefits, as envisaged by Hjelm [34], are based on preliminary results, opinions and predictions, which are necessary due to a lack of useable information. Some of the benefits of telemedicine include:

- remote diagnosis with specialist support;
- home monitoring;
- improved access to medical information;
- medical care to people who would not otherwise have received treatment;
- increased range of healthcare delivery;
- professional support to health education programmes and workshops;
- improved support for professional education; and
- potential reduction in healthcare costs.

The above-mentioned benefits are not the only ones, but they are some of the more common benefits mentioned when suggesting telemedicine as an alternative to the current setup [34].

2.9 Drawbacks of Telemedicine

Although telemedicine has a wide range of potential benefits, as discussed in the previous section, some disadvantages are also associated with telemedicine in general. Based on some preliminary results pertaining to telemedicine projects and predictions, Hjelm [34] identified some drawbacks that can be associated with telemedicine projects, these are:

- a breakdown in the relationship between patients and healthcare professionals;
- a breakdown in the relationship between healthcare professionals;
- information quality issues; and
- bureaucratic difficulties.

The drawbacks of telemedicine are discussed further in the next few sections due to the direct impact some of them might have on the project discussed in this document, particularly the impact of information quality issues and bureaucracy on telemedicine in South Africa.

2.9.1 Relationship Breakdown between Patient and Health Professional

The relationship between a patient and a healthcare professional is of the utmost importance for effective working of a telemedicine system. Physical and mental factors, depersonalisation, a different process of consultation, an inability to perform a comprehensive consultation, reduced confidence in patients and healthcare professionals, and the different knowledge and skills required by healthcare professionals are some of the factors which can cause a breakdown in this relationship [34].

2.9.2 Relationship Breakdown between Health Professionals

A breakdown in the relationship between healthcare professionals involved in telemedicine has not been explored to any great extent, but the risk exists and can have a potentially negative effect on the efficiency of telemedicine projects. A major contributing factor leading to a potential breakdown in the relationship is the threat to the autonomy of the healthcare professional situated in the remote area. They could perhaps be viewed as no more than a technician acting solely on the advice/diagnoses provided by the specialist. The specialist would then receive all the acclaim for successfully treating the patient [34].

2.9.3 Information Quality Issues

There is a wealth of medical information, especially on the Internet. This information can be broadly divided into three categories. The first category includes textbook-style information, produced by medical schools and academic institutions. The second category contains abstracts of peer-reviewed articles or entire articles from biomedical journals. The *Journal of Telemedicine and Telecare* is an example of such a biomedical journal in the field of telemedicine. The third category has to do with pamphlets and articles intended for the general public. This information is aimed at being informative and creating awareness of certain issues [34].

Inaccurate and confusing information, generally associated with the third category, is cause for the greatest concern. Medical information, which should be based on research and facts, is sometimes not complied with when information is transferred by means of a platform intended for the general public [34].

In some instances, the amount of information is overwhelming which makes finding relevant and accurate information pertaining to a specific topic or project, as is the aim of this project, a

daunting task. The quality of information is critical to the success of this project, hence the emphasis on it.

2.9.4 Bureaucratic Difficulties

The fact that telemedicine might have great potential for improving healthcare delivery does not necessarily mean that it will be implemented. The different role players involved in the various stages of the telemedicine project play a vital role. Little evidence exists to suggest that manufacturers and developers, who are capable of developing suitable products and systems, and politicians, who are in a position to ensure suitable funding and political support for the developed product or system, will play along. It is also not a given that health administrators, who could improve the current process of health service delivery by utilising and implementing the newly developed telemedicine product or system, and health professionals, who can assist in the development and implementation of the product or system, are particularly interested in doing so.

This is an important consideration, since the information system developed and discussed in this document will have to address the involvement of the different role players and bureaucracies in telemedicine projects in South Africa. Their promotion of and support for the documenting of telemedicine projects in South Africa is thus another crucial issue.

2.10 Barriers to Telemedicine Implementation

The successful implementation and operation of a telemedicine system faces many obstacles. A study by Wayne Bell [35], utilising project data obtained from the Telemedicine Information Exchange website, attempted to summarise the barriers encountered when implementing telemedicine systems. At the time of the study there were approximately 140 projects listed on the website. Table 2-1 shows the barriers as cited by enterprises practicing telemedicine.

These barriers are not unique to telemedicine applications, systems engineers have been dealing with similar problems, when introducing technology into other businesses, for some time. The barriers described in Table 2-1 will also, to some extent, impact on the information system discussed in this document. It is thus important to understand the possible effects the barriers might have on the development and implementation of the information system.

Understanding the barriers and developing contingency plans to address certain issues before they occur, will reduce the impact of these barriers on the project.

Table 2-1: Barriers encountered when implementing telemedicine systems [35].

Physician Acceptance and User Skills	20%
Reimbursement Issues	20%
Other*	19%
Cost (Initial & Operating)	17%
Inadequate Technology	11%
Funding	8%
Licensure	5%

* Profitability, rapid technological obsolescence, malpractice, community commitment and lack of a cost benefit evaluation

Acceptance by physicians, and user skills, are two of the barriers that will certainly play a role in the implementation of a new telemedicine system. A system cannot function properly if the person it is supposed to support does not back the project. It is thus important to involve all the key role players in the project and get them to openly endorse it.

The costs associated with the development, implementation and operation of the system always plays a pivotal role. A primary focus of the information system to be developed in this project is to keep costs as low as possible. A mixture of open-source and licensed software will thus be used to reduce costs. The licensed software and server space for the information system will be provided by Stellenbosch University. The MRC will provide financial assistance for training and certain operational procedures.

Another important barrier that must be taken into consideration is the use of inadequate technology. This applies to both users and developers; certain limitations will be enforced on both parties and restrictions on the availability of development tools are a possibility for the developer. In addition, the user may be restricted to a certain version of an Internet browser which would also impact on the developer, and contingencies should be in place to avoid errors if these were to arise.

2.11 Conclusion

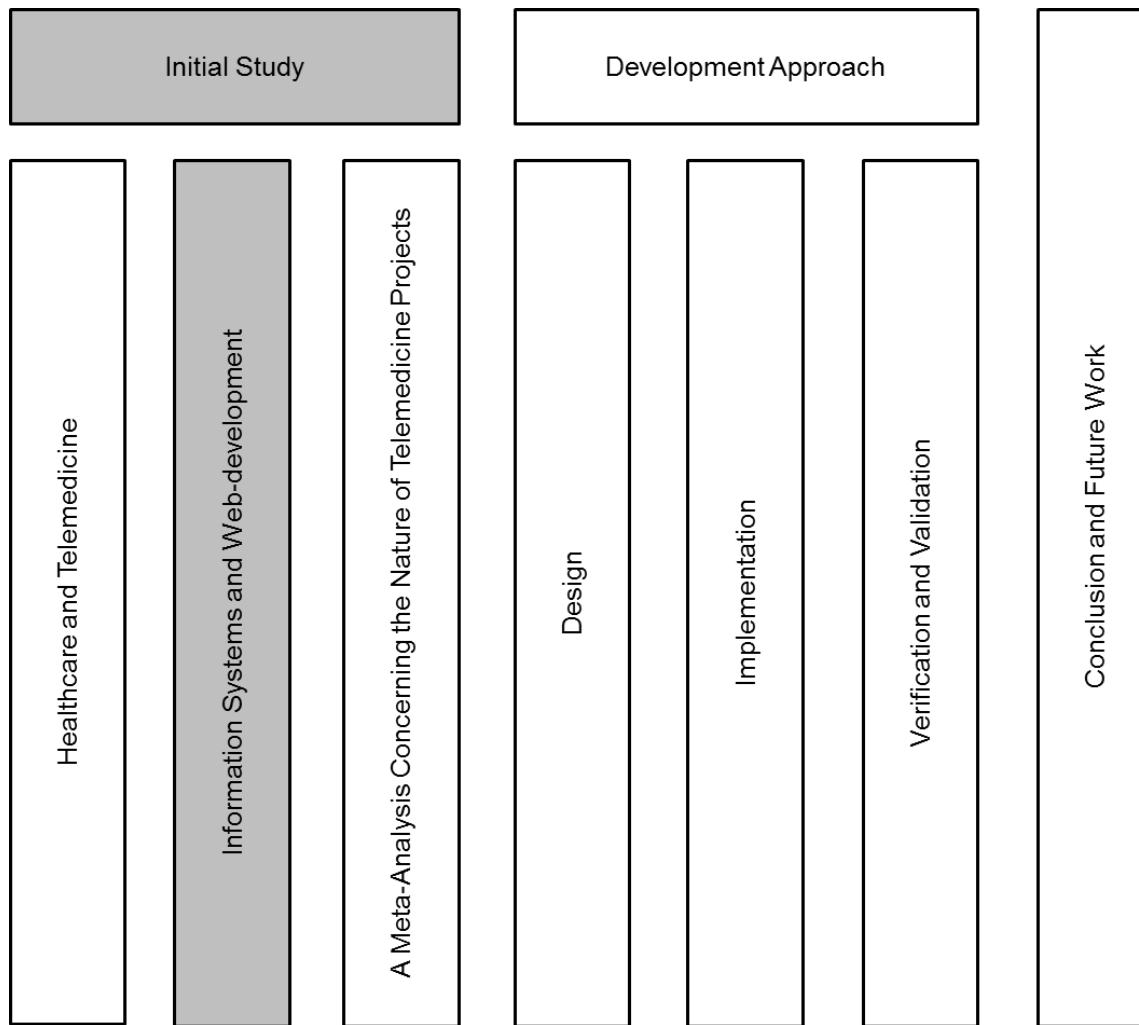
This chapter gave an overview of telemedicine and its possible link to the healthcare situation in South Africa. The status of telemedicine in South Africa was also discussed. Various topics, including the history of telemedicine, the definition of telemedicine, the types of telemedicine, and the MRC and their role in telemedicine in South Africa were discussed.

Factors that will influence the development and implementation of the information system were also mentioned in this chapter. Special emphasis should be placed on telemedicine applications, possible drawbacks of telemedicine systems and potential barriers to the implementation of telemedicine systems. The benefits were mentioned as an incentive to ensure that role players in the telemedicine community stay motivated. These incentives can also be incorporated into the final information system to ensure the system stays active.

The next chapter will focus on information systems. The software and hardware required to develop and implement an information system will also be discussed.

3. Information Systems and Web-Development

This chapter describes aspects of information systems development and web-development components, including the software and hardware, as well as development techniques, required for the establishment of an information system. The various components that play a part in the development, implementation and operation of the information systems are also mentioned and discussed.



3.1 Information Systems

All people use information in their personal and professional lives, but most fail to appreciate that in order to maximise its usefulness, it must be properly managed. People are bombarded with information on a daily basis, but manage to filter out the important information without difficulty. Simple, non-computerised, information systems such as a date book, address book, or a simple computer based programme, are used to filter the information people want to retain.

At an organisational level, due to the volume or complexity of information being processed, the importance of the information to the organisation, and the difficulty of sorting and interpreting the information, careful control, a systematic approach, and a refined analysis is required. Increasing the rigour of information management normally involves the development of more complex, formal, typically computerised systems that collect, organise, retrieve, and communicate information [36].

The term “information system”, as defined by the Software Institute Report, refers to the use of any combination of information on technology and people’s activities using that technology to support operations, management, and decision-making [37]. The classic view of information systems found in textbooks is that of a pyramid of systems that reflect the hierarchy of the organisation [38]. According to Kendall [9], the categories included in the pyramid are:

1. Decision Support System (DSS)
2. Executive Information System (EIS)
3. Management Information System (MIS)
4. Transaction Processing System (TPS)

Figure 3-1 illustrates the structure of information systems with regards to the different hierarchical levels in an organisation. This indicates that information systems are capable of being integrated into all aspects of an organisation, from the workers on the floor level to the executives.

Although new technologies have been developed and new categories of information systems have emerged, the pyramid model remains useful. Some examples of systems which do not fit easily into the pyramid model are data warehouses, enterprise systems, global information systems and office automation, amongst others. For the purpose of this study, the pyramid

model representing the types of information systems is apt, since the system being developed fits into the model. This will be discussed in the next section.

The needs of the users of the information system often determine which type is most appropriate for the given situation. Sometimes, a combination of two or more types of information system is required to address the needs of the consumer.

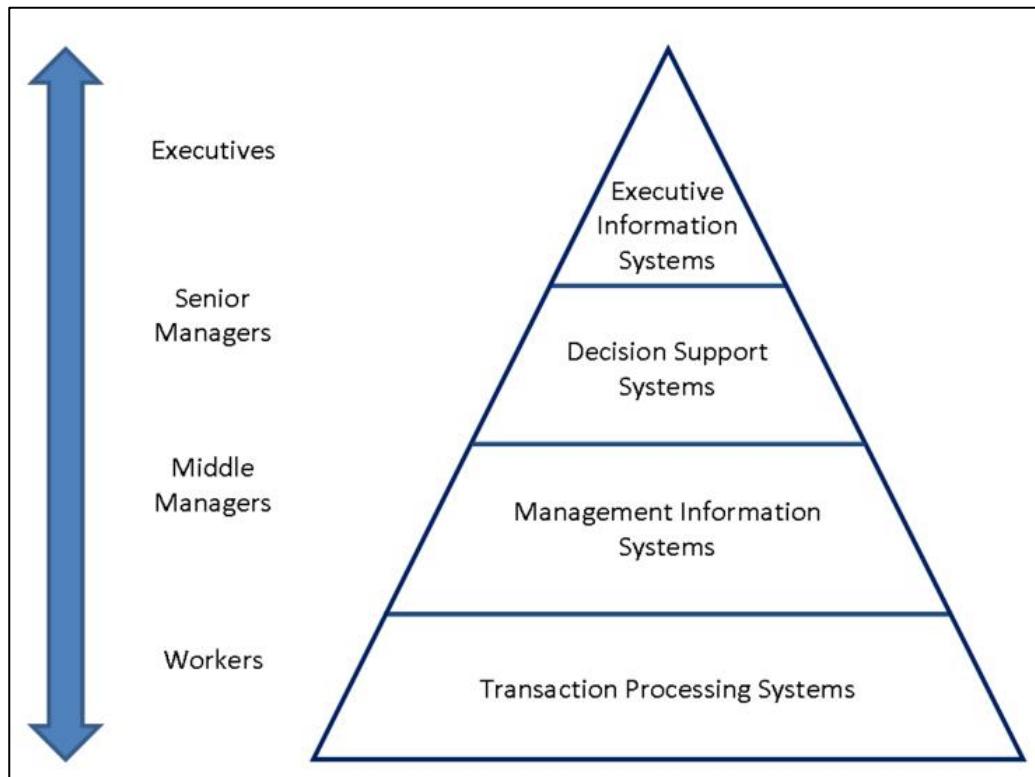


Figure 3-1: The four level pyramid model of information systems with regards to different hierarchical levels in the organisation.

The next few sections will describe the four main types of information systems. Specific focus will be placed on management information systems and decision support systems. The reason for the focus on these two is because they are the most appropriate type of information systems for the purpose of the project, as will become evident as the discussion progresses.

3.1.1 Decision Support Systems

Decision Support Systems (DSS) have emerged as a topic of great interest to computer users, business managers, academic researchers, and computer industry vendors over the past few years. It has replaced MIS as the trend application area for computer utilisation in business [39].

This new direction in information systems indicates an important turning point in how organisations utilise their computerised environment. Instead of looking to systems output as a periodic report or an answer to a recurring question, DSS view output from a different perspective. They specifically use the decision maker's insight, judgement, and past experience at various stages of problem solving, when interacting with the computer [40].

Decision Support Systems can be defined as:

"Interactive computer-based systems that help people use computer communication, data, documents, knowledge, and models to solve problems and make decisions [41]."

DSS is a field or an area of interest which attempts to bring together and focus a number of independent disciplines, as shown in Figure 3-2. The interest in affecting decision making in organisations is what brings these disciplines together in the DSS field. DSS attempt to integrate these independent disciplines, and thus to incorporate separate technologies to apply to decision making in organisations. Such integration is not easy since most of the stakeholders of the DSS are interested only in their particular "home discipline" [39].

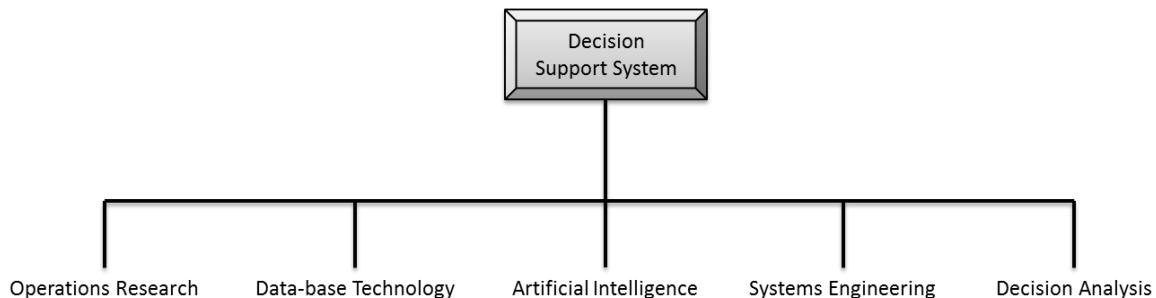


Figure 3-2: Independent disciplines supporting decision support systems

Database technology and systems engineering are the important components of DSS which will influence the design and development of the information system in this project. Decision analysis will also be incorporated into the information system, but to a lesser extent due to the fact that the user will be able to utilise the information obtained from the information system to assist in decision making.

DSS are similar to traditional MIS because they too depend on a database as a source of data. A DSS departs from the traditional MIS because it emphasises the support of decision making in all its phases, although the actual decision is still the exclusive province of the decision maker [9].

It is important to note that Decision Support Systems are not exclusively associated with mathematical analysis in providing a calculated decision. An information system that provides information to assist the user in his/her decision making process is also a form of decision support. Hence, the use of a hybrid system that utilises the information gathering and retrieving capabilities of a MIS and the decision support capabilities of DSS is used in the design and development of the information system in this project.

The type of decisions supported for the purpose of this study includes the ability to identify if there is sufficient backing and related projects to implement the suggested telemedicine project. The information gathered by the information system will also provide insight into the successes and failures of a project, allowing funders to re-evaluate their position regarding the telemedicine project. The information system will also identify projects in a given region, allowing the user to make an informed decision in terms of the possible future success of a project with regards to that specific region.

3.1.2 Executive Information Systems

An Executive Information System (EIS) is neither hardware nor software, but rather a form of infrastructure that supplies a firm's executives with up-to-the minute operational data, gathered and sifted from various databases. Typical information presented by the system may include financial information, work in progress, inventory figures, sales figures and industry statistics, amongst others. In some instances the EIS may even suggest what needs to be done, similar to a decision support system. The difference between DSS and the EIS is that the EIS is targeted at executives instead of managers [42].

3.1.3 Management Information Systems

A management information system is a system that provides information needed to manage organisations efficiently and effectively [43]. Management information systems normally consist of three primary resources namely; technology, information, and people. The most important resource of the three is people.

Management information systems are regarded as a subset of the overall internal controls procedures in a business. They cover the application of people, documents, technologies, and procedures used by management accountants to solve business problems such as costing a

product, service or a business wide strategy. Theoretically, the term is commonly used to refer to a group of information management methods tied to the automation or support of human decision making; including decision support systems, expert systems, and executive information systems [44].

Management information systems focus on providing the management of an organisation with the appropriate information to make the necessary decisions. By requiring people, software (computer programmes), and hardware (computers and printers amongst others) to operate in accordance with each other, management information systems supports users in accomplishing a broader spectrum of organisational tasks, including decision analysis and decision making [9]. If the appropriate information is stored correctly and is easily retrievable, it can enhance the decision making abilities of the user considerably. This is why this type of information system is applicable to the development of an information system for telemedicine projects in South Africa.

The aim of the information system in this study is to document (store) and share (retrieve) information relevant to telemedicine projects in South Africa. Utilising the framework of a management information system, as basis for the information system and then customising it to fit the needs of the end users will be beneficial and time-efficient, whilst also providing structure to the project.

3.1.4 Transaction Processing Systems

Transaction Processing Systems (TPS) are the floor level information systems which are used to drive the company. Some of the operations of typical TPS include collecting, storing, modifying and retrieving transactions of an organisation. TPS are common and used in a wide variety of industries.

For the purpose of the information system proposed in this study, the transactional processing framework will not form part of the information system due to no transactional capabilities being required. The next section will focus on the components required for the successful development and implementation of the information system proposed in this study.

3.2 Components of an Information System

In order for a computer-based information system to function properly, certain key components have to be integrated. The five main components required for a computer-based information system are; computer hardware, computer software, telecommunications, databases and data warehouses, as well as human resources and procedures [45].

3.2.1 Computer Hardware

Most people today own some sort of microcomputer, also known as a personal computer. Individuals may own multiple computers in the form of laptops, desktops and smartphones, which are integrated into some type of information system, for example; social networking or online banking. Large organisations often employ distributed computer systems integrated into the organisational information system. In recent years, hardware costs have decreased steadily, whilst processing power and storage capacity has increased drastically, allowing more complex and demanding information systems to be developed [45].

Figure 3-3 shows the basic architecture of an information system. The main hardware components include a hosting server, user computer (laptop or desktop), developer computer (laptop or desktop) and some form of network or internet connection, depending on the location where the information system is hosted.

Detailed information pertaining to hardware components such as CPU (central processing unit), GPU (graphical processing unit), network speed, and others, are not necessary due to the fact that the infrastructure that will be used is already in place. Stellenbosch University has dedicated servers with local and internet facing capabilities. Thus, the hardware components to be utilised are fixed, but certain software capabilities can be tweaked according to the needs of the developer. It is however important to note that these hardware components can have an impact on the performance of the information system, and user experience will vary depending on the location.

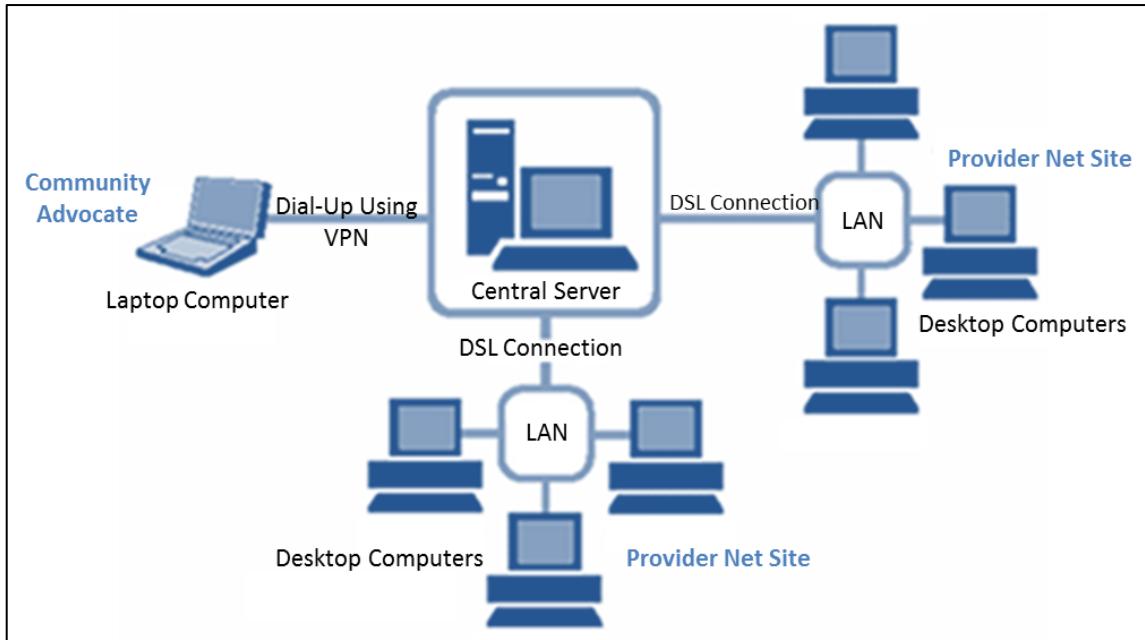


Figure 3-3: Basic Information System Architecture

Utilising the existing infrastructure reduces costs and bandwidth requirements. However, certain limitations are placed on the developer, but this will be discussed at a later stage. The next section focuses on the computer software requirements of the information system. This includes system- and application software.

3.2.2 Computer Software

Many software products and methods exist to develop, implement and operate an information system. Personal preference and system requirements often dictate which type of development and operating software is utilised for the information system. The focus in this section will be on back-end and front-end development tools, since the operating software on the server are pre-determined and cannot change. A brief discussion pertaining to server software, which include limitations and options, and end-user software requirements will follow the discussion on front- and back-end development software.

3.2.2.1 Back-end Development Software

The back-end development software refers to software products that are capable of developing databases whose primary function is to store and retrieve data, as requested by other software applications. Back-end does not only refer to databases, but to all of the processing required to

create the front-end (visual interface) for the system. This includes security features such as; user authentication (login and authorization) and restricting access to certain parts of the system by assigning roles to users.

The two software tools that will be discussed for the development of the database are; Microsoft SQL Server and Microsoft Office Access. Both products are developed by Microsoft to serve as a database tool, but they have different applications and target audiences.

Microsoft SQL Server

Microsoft SQL Server is a relational database management system developed by Microsoft. The primary function of this software is to create a database to store and retrieve information. There are a variety of different editions to cater to the different demands of users, ranging from small applications with low data flow, to server applications with a lot of data flow.

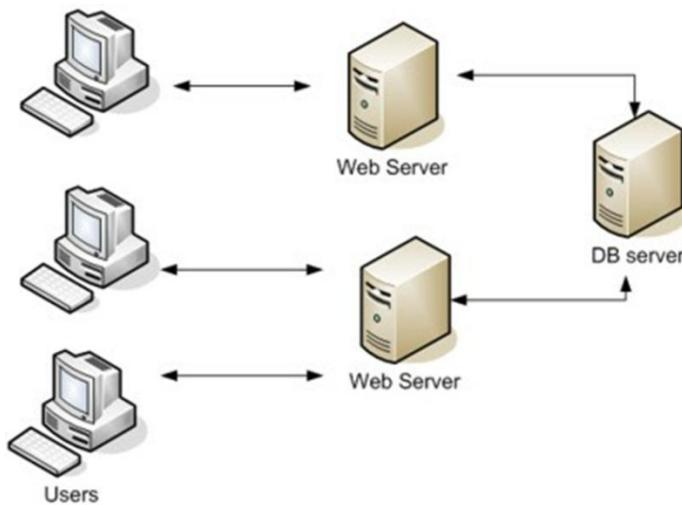


Figure 3-4: Typical SQL Server Database Architecture

Figure 3-4 illustrates the typical database architecture if a SQL Server database structure is used. The database is stored in a separate server from the website files. A connection is coded into the website configuration file, telling the website where to locate the database. The database will contain the user login information such as a username and a password.

By hosting the database in a separate server, more customised options are available to the developer. The allowable expansion size of the database is also increased, compared to a database hosted on a multi-platform server. The one issue is that there is an additional

connection to a remote location (to the database) which must be encrypted to ensure and adhere to privacy regulations.

Microsoft Office Access

Access is a program that allows users to create a database as well as develop forms to capture the data. Access also allows queries to be implemented. It is similar to SQL server (database developer for exclusive use with websites capable of handling a large amount of internet traffic simultaneously), but Access is more user-friendly and allows the database to be utilised without a website or a dedicated server.

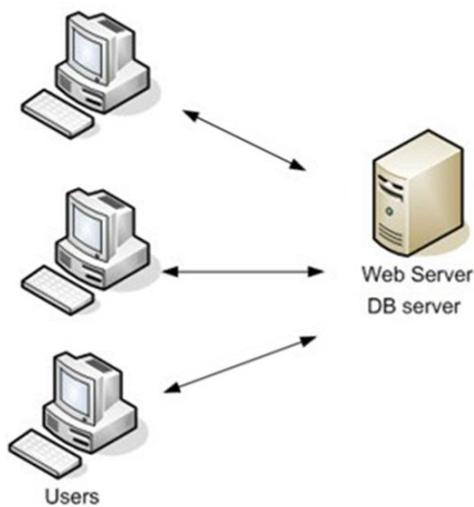


Figure 3-5: Typical Access Server Database Architecture

Figure 3-5 illustrates the typical database architecture if Microsoft Access database is used. Unlike the SQL server database, the Access database can be hosted on the same server as the website. This eliminates the connection that has to be built to another server to access the database.

Since the 2007 version of Microsoft Access, the database extension has changed from “.mdf” to “.accdb.” This is important, since most servers still require the Access database to be in the “.mdf” format. It does not mean that an older version of Microsoft Access has to be used during development. The database that is created has to be exported in the “.mdf” format to ensure that it is compatible with the server. If the server has the latest software version installed, this will not be an issue.

A drawback of using a Microsoft Access database is that it is limited to the amount of simultaneous traffic it can handle. The maximum size of the database allowed is also considerably smaller than that of a SQL database.

Selecting the correct database will depend on expected traffic and server capabilities. If a large amount of traffic has to be used simultaneously, SQL is the better option. If the amount of data that has to be stored is limited and the number of users is not too large, Microsoft Access is the better option. Also, working with Microsoft Access is easier and more user-friendly than working with SQL server.

3.2.2.2 Front-end Development Software

Front-end development software's primary focus is on creating a graphical interface, which hides the processes running in the background. For the purpose of this study, the front-end will refer to the website the user will interact with. To create the front-end of an information system, the necessary software is required.

There are many software programmes, applications, techniques and methods to develop the interface of an information system. These programmes range from coding the entire website in Microsoft Notepad (standard application that comes free with Microsoft Windows operating system), open-source programmes developed by enthusiasts and mainstream corporate programmes.

Two companies, Microsoft and Adobe, provide web-development software that is proven to be compatible with database development programmes mentioned in the previous section. Both these companies also provide online support and have a dedicated community which assist developers in solving problems. This is useful to a developer due to the fact that technology evolves at a high rate and it is not always possible to find solutions to problems in literature. Microsoft Visual Web Developer Express and Adobe Dreamweaver are the two programmes that will be discussed in more detail. Some smaller and less known programmes and methods, which achieve similar results, will also be discussed.

Microsoft Visual Web Developer

Microsoft Visual Web Developer is a full-featured web development editor for working with web standards, JavaScript (universal coding language) and ASP.NET (application to develop active server pages for websites). An advantage of using Visual Web Developer is that the code is auto

generated. This implies that the user can work in a design view that allows him to drag and drop various objects onto the work space whilst the code is generated in the background. The user also has the option to modify the generated code to further customise the website.

Another useful feature of Visual Web Developer is that it integrates databases into the website seamlessly. A user first has to select the type of database he wants to connect to the website, drag the applicable object onto the work space and then connect to the database by browsing for it using the object browser. Figure 3-6 illustrates the method for connecting to a database, using Visual Web Developer. This is a useful feature if the information system has many connections to the database.

Visual Web Developer also utilises Microsoft's ASP.NET framework. It is a web application framework developed and marketed by Microsoft to allow programmers to build dynamic websites, web applications and web services. Visual Web Developer has a standard ASP.NET template which automatically adds user authentication and security to the website.

The integration of Microsoft Visual Web Developer and Microsoft SQL Server reduces a lot of effort, on the part of the developer, of adding these features to the website, since it is automatically created by the ASP.NET template. A drawback, however, is that not all hosting services are capable of running SQL and ASP.NET on the same server. Since Visual Web Developer automatically creates a SQL Server database, converting it to a different database type (to be compatible with the server specifications) can be problematic.

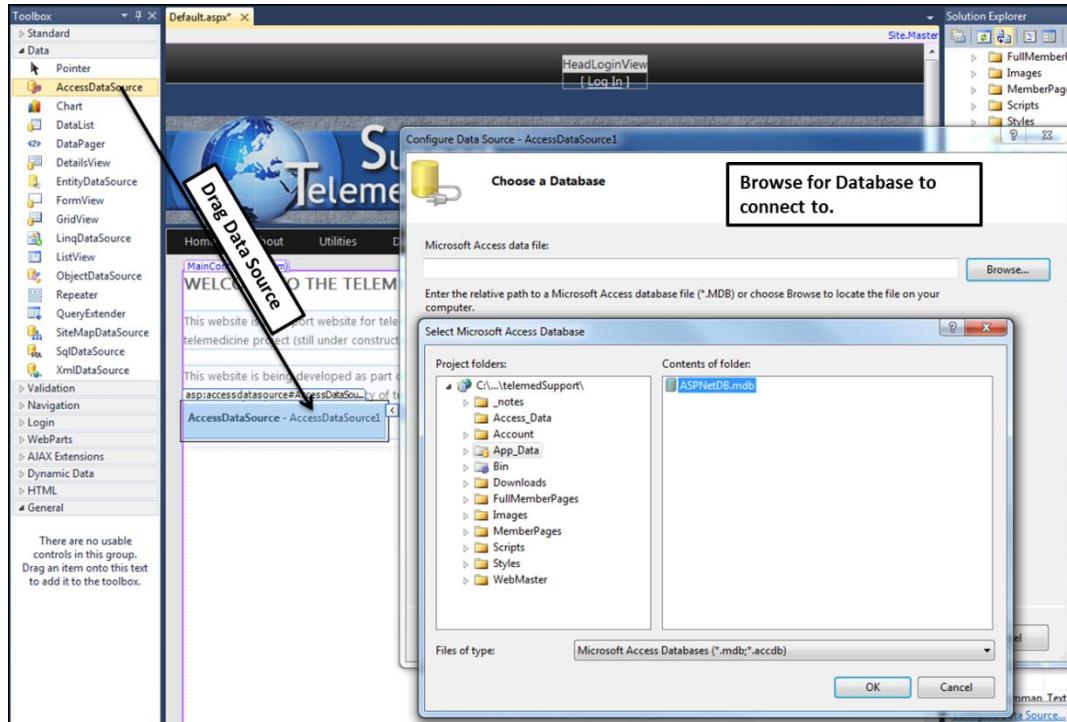


Figure 3-6: Example of how to connect to a database using Visual Web Developer

The type of website that is to be developed often dictates the software that will be used. It is however not uncommon to use multiple products to address different aspects in the development. Visual Web Developer is good at handling and incorporating databases into a website. For design, Visual Web Developer is limited and does not offer the design tools some other programmes offer the developer. Adobe's Dreamweaver is a popular web design tool that offers a lot to a developer in terms of design tools.

Adobe Dreamweaver

Adobe Dreamweaver is a professional web design programme which offers a lot of power and flexibility to both the developer and the designer. The user-friendly interface creates an environment for novice and advanced users.

Adobe Dreamweaver is supported on both Windows and Macintosh operating systems. It supports most coding languages, including HTML, CSS, PHP, JSP, XML, and JavaScript [46]. Due to its popularity as a web design tool, Adobe Dreamweaver has a large technical and development support platform, providing the developer access to a great deal of support content on the internet.

One of the drawbacks of Adobe Dreamweaver is that it does not have a built in testing server, unlike Visual Web Developer where it is included as an option during the installation of the programme. This can be problematic for a developer who needs to test the system if it includes databases. However, the problem can be circumnavigated by creating the testing server manually, but it requires an experienced user. In addition, Adobe Dreamweaver lacks the security features that come standard with the Visual Web Developer ASP.NET template.

It is for these reasons that Visual Web Developer is preferred as the standard front-end development tool for the information system proposed in this study. However, for certain design features and interaction with the hosting server, some of Adobe Dreamweaver's features will be utilised. This will be discussed at a later stage.

3.2.3 Telecommunications

An important component of any information system is the connection between the user and the information system. Telecommunications are used to connect computer systems and transmit information. These connections can be wired or wireless, depending on the situation [45].

It is important to incorporate the type of communication into the design of an information system. Capabilities and limitations vary and may have an impact on system performance. A system developed in a European country, where internet coverage and data transfer speeds are generally high, will differ from a system developed in South Africa, where internet coverage and data transfer speeds decrease in remote areas of the country.

The telecommunications infrastructure is a fixed component, thus the developer has to design the information system in accordance with it. Although the developer cannot necessarily change the communication infrastructure, unless the purpose of the information system is to only cater for a local area network, techniques to reduce data transfer requirements and inconsistent internet connections must form part of the information system design.

3.2.4 Databases and Data Warehouses

Information systems are primarily delivery vehicles for data stored in databases. A database is a collection of records organised so that individual records or groups of records can be retrieved to satisfy various criteria. Examples of databases include user information and product

catalogues which can be found all over the internet. Databases support the operations and management functions of an enterprise [45].

Data warehouses contain archival data obtained from the databases over time, and can be mined for information using various data techniques. The information retrieved can in turn help to develop and market new products, serve customers better, or reach new customers [45].

The software tools required to develop these databases and data warehouses were already discussed in 3.2.2.1 on page 36. The databases and data warehouses are the fundamental building blocks of an information system. It is for this reason that the utmost of care must be taken when designing and developing the database. This will ensure that the information system functions efficiently and the effort required to maintain the information system is reduced.

3.2.5 Human Resources and Procedures

Qualified people are a vital component of any information system. The personnel involved with an information system include development and operations managers, business analysts, systems analysts and designers, database administrators, computer programmers, computer security specialists, and computer operators. The personnel of an organisation must be trained to utilise the full capabilities of the information system in order to fully appreciate its benefits. As people are becoming more technically capable, web-based information systems are becoming more popular and in some instances they have become part of many people's daily routine [45].

The procedures, for using, operating, and maintaining an information system, form part of the information system's record. For example, procedures need to be established to run a payroll programme, including when to run it, who must authorise the running of it, and who has access to the output [45]. All of this must be taken into account by the developer of the information system. It is for this reason that the development process of an information system is well documented and contains a lot of pre-planning steps and design methods before the actual system is built.

3.3 Conclusion

In this chapter, the different types of information systems, as well as the general components of an information system, were discussed. It is worthwhile to note the importance of selecting the

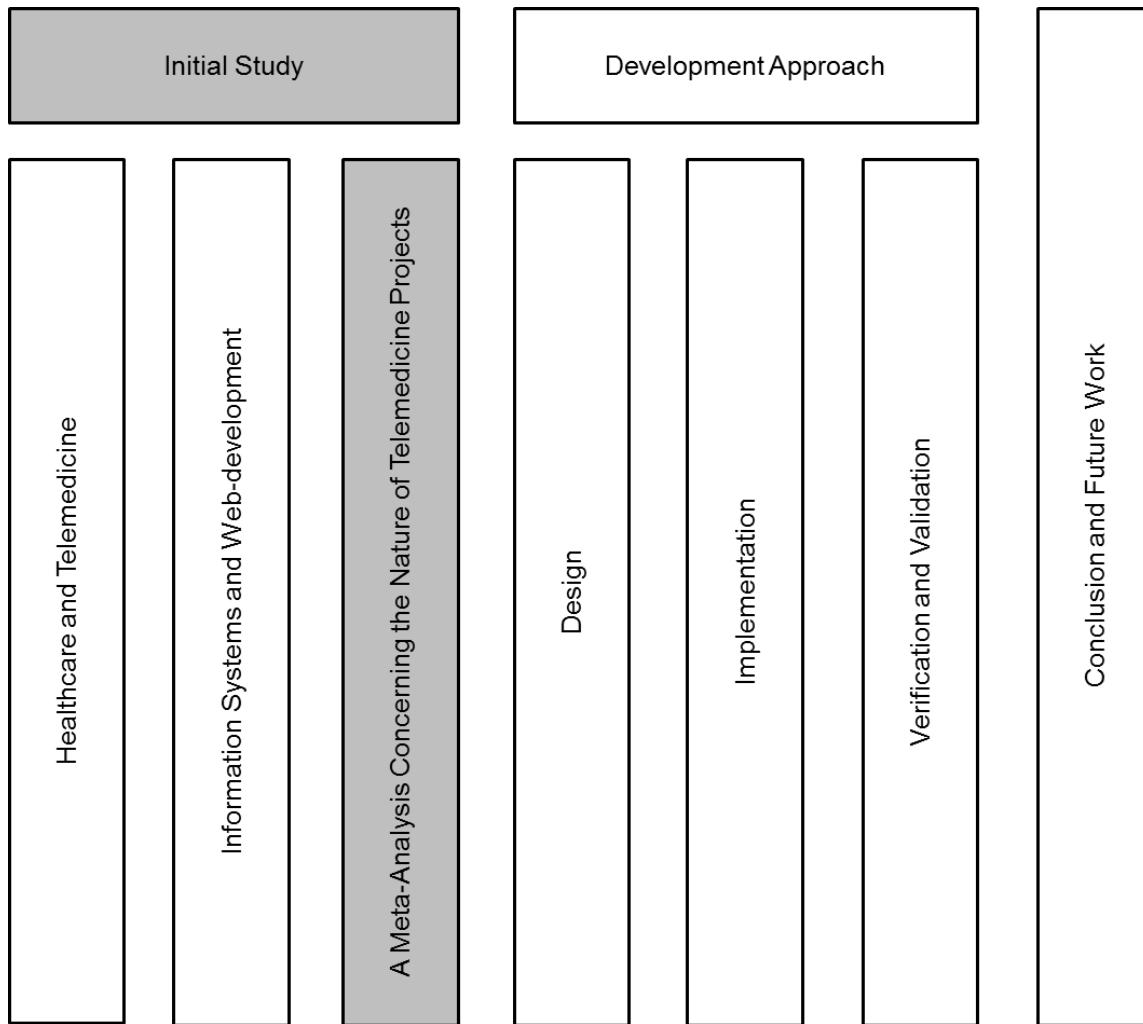
correct hardware and software tools to design and develop the information system, as this will have a major influence on the capabilities of the system.

Although certain components of an information system, such as the telecommunications infrastructure and human resource skill capabilities, are fixed and cannot be physically altered by the developer, the developer can incorporate these component limitations into the system. This will make the information system more user-friendly and reliable.

The next chapter will discuss the design and development of the information system proposed by this study.

4. Meta-Study

The purpose of this project is to provide a rationale for telemedicine in South Africa. One of the problems surrounding telemedicine is that the majority of publications on the topic relate to projects in isolation [47]. A meta-view on the nature of telemedicine is thus lacking. In this chapter, an empirical study is conducted to investigate the nature of telemedicine projects.



4.1 The Telemedicine Process

For an information system to be effective, it has to collect the correct information that is relevant and useful to the various stakeholders. When developing a database, it is important to know the type of information that will be collected. This will ensure that the database being developed is robust and is capable of handling the information entered into it.

For the purpose of the meta-study, the process for a given telemedicine system is analysed. The definition provided by the South African Department of Health on e-health and telemedicine is used as a reference point. This definition provides a structured view identifying the various phases involved in the process.

The definition states (from section 2.2):

*“Telemedicine and e-Health is the combined utilization of electronic communication and information technology to **generate, transmit, store and retrieve** digital data for clinical, educational and administrative purposes.”*

From the definition provided by the Department of Health, a process can be derived which will allow the information system to collect the relevant technical information. The main components involved in the telemedicine process are generating, transmitting, storing, and retrieving information. To generate the data, information has to be collected by a person or a piece of equipment. Also, the purpose of telemedicine is to provide medical care over a distance, implying that a diagnosis of some sort has to be made. Finally, to complete a process, the diagnosis has to be administered to the patient or retrieved by the onsite diagnostician.

The telemedicine process consists of sub processes starting with the collection of data up until the moment when the diagnosis is administered. This includes the packaging, transmitting and retrieving of data at various stages throughout the process.

The first step in a thorough examination process suggests a strategy of critical inquiry. Basic “what”, “where”, “why”, “when”, and “how” questions need to be answered systematically to ensure consistent answers before any new effort can be endorsed or accepted.

Figure 4-1 shows the graphical representation, derived from the definition, of the telemedicine process. The telemedicine process will serve as the core component for the purpose of the meta-study. The design and development of the database and interface responsible for storing and retrieving the telemedicine process data is discussed in Chapter 5.

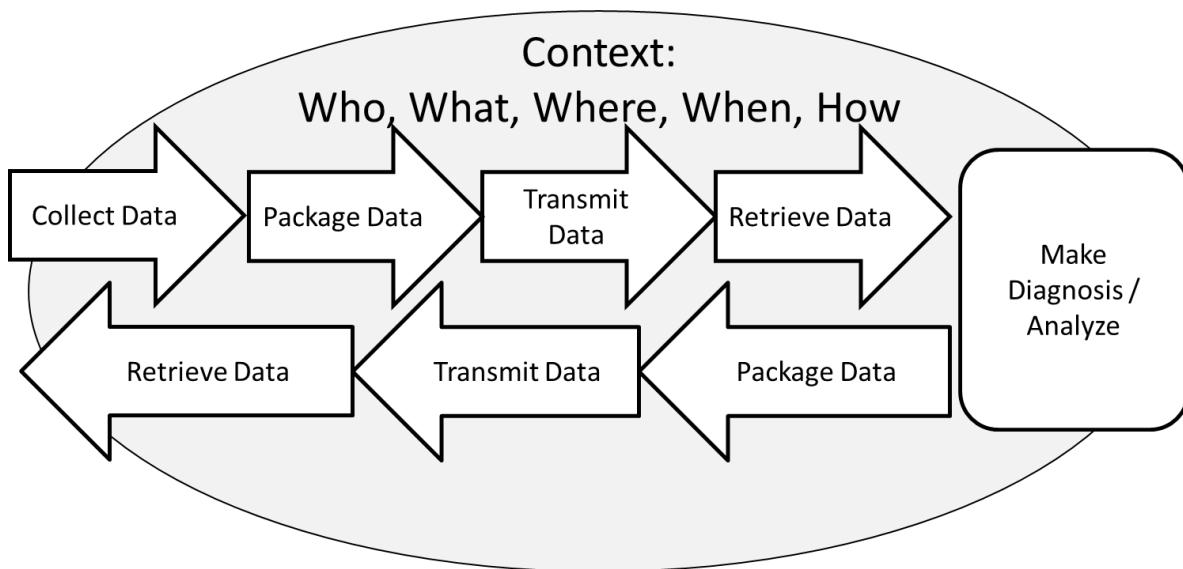


Figure 4-1: The Telemedicine Process

The telemedicine process, pictured above, is a generic model designed to be compatible with the majority of telemedicine projects. The telemedicine process is used throughout the meta-study to document telemedicine projects sourced from literature. The next section discusses the *Journal of Telemedicine and Telecare*, which will be used as a literature source for collecting information pertaining to the telemedicine process for various telemedicine projects.

4.2 The Journal of Telemedicine and Telecare

The *Journal of Telemedicine and Telecare* provides information on developments in telemedicine and e-health. It is widely recognised as one of the leading journals in the field of telemedicine and has had an impact factor of 1.207 (effective from January 1, 2012) [48]. The articles published in the journal focus on clinical trials of telemedicine applications from around the world [49]. This provides a unique perspective on how different countries and health systems are using new technology in healthcare. The journal includes sections containing original articles, review articles and reports from various telemedicine organisations.

4.3 Performing the Meta-Study on Telemedicine Projects

A three day study was arranged where four industrial engineering students from Stellenbosch University were recruited to populate a database based on the telemedicine process. Information from articles was provided to each student and was used to gather information.

4.3.1 Preparation

For the purpose of the meta-study, 102 articles, describing various telemedicine projects, irrespective of the country where the project was performed, were selected from the *Journal of Telemedicine and Telecare*. The dates of the articles, selected for the study, ranged from 2006 to 2011. This, together with the international diversity of the articles, ensured that the information entered into the system was from a wide variety of projects culminating in an effective definition of the elements of typical telemedicine processes, based on a systematic study.

Articles were selected based on the title and the abstract, since these indicated whether the article addressed either a specific telemedicine project or a quantitative analysis/review. Only the articles indicating a discussion of a specific telemedicine project were selected for the meta-study. The number of articles selected was determined by the number of participants and the amount of time available. Five articles per student had to be documented on the first day, followed by ten articles, per student, over the next two days.

Prior to the students being allowed to use the information system, two of the articles had to be consulted to test the integrity of the database and the input forms (development discussed in Chapter 5). No problems occurred during this initial process and the data obtained from the two articles were included in the meta-study. The reason for only five articles being given to each of the students on the first day was to allow the students to familiarise themselves with the information system and to perform a consistency test.

Before the five articles were uploaded, a test was performed to identify the level of consistency that existed between each of the students. The students were given the same three articles and they then proceeded to document the articles on the information system. These articles did not form part of the meta-study and were used only for testing purposes.

A comparison was then made between the four students and the entry fields for each article (see Appendix A for the comparison). For example, if all the students selected the same value

from the drop down list for a field, a 100% similarity was awarded for that field. If three students selected the same option, 75% was awarded and if two students selected the same option, 50% was awarded. Table 4-1 is a summary indicating the aggregate similarity of the students for each article.

Table 4-1: Aggregate similarity of the students for each article

	Article 1	Article 2	Article 3
Total Similarity Percentage =	75%	70%	77%

The percentages recorded in the table indicate that, on average, three of the four students selected the same option for a given field. This is a good result, considering that each article documentation form contained 52 data entry fields.

4.3.2 Collection

The article documentation form consisted of 52 data entry fields. These were made up of the telemedicine process information (40 data entry fields) and the additional descriptive information about the project and article (12 data entry fields). The telemedicine process consisted of eight steps; including a critical inquiry at each step, as shown in Figure 4-1. The descriptive information included such information as the name of the project, the type of disease, the implementation layer of the project and the country where the project took place.

The form used to document the articles can be seen in Appendix C.

Each student was given a set of 25 articles, with each article documenting a specific telemedicine project. The students then had to complete the telemedicine process form (see Appendix D) for each article. If the appropriate option was not included in the drop down list field on the form, the student could add this information to the drop down list field using another form. This new selection option was then made available to all the students.

A total of 102 articles (25 articles for each of the four students and the two articles uploaded to test the information system) were documented during the meta-study. The 5304 data points, collected during the study, were derived from multiplying the 52 entry fields per article, with the total number of articles documented.

4.4 Exporting and Organising the Data

In order to utilise and analyse the data, stored in the database, it had to be exported to a platform where it could be edited. For the purposes of this study, Microsoft Excel was used to sort and organise it into a manageable format.

Table 4-2: Summary of the Telemedicine Projects - The Top Three most selected fields in each category.

	Who	What	When	How	Where	
Collect	Patient 33	Medical Information 20	When Necessary 39	Videoconferencing Equipment 11	Home 32	
	Nurse 12	Images 14	As Soon As Possible 18	Digital Camera 10	Hospital 16	
	Doctor 12	Medical Information and Images 9	Scheduled Meeting 12	Mobile Phone 9	Rural Hospital 11	
Package	Patient 30	Medical Information 26	At Completion of Previous Step 82	Computer 24	Home 28	
	Nurse 10	Medical Information and Images 12	N/A 4	Videoconferencing System 20	Hospital 10	
	Doctor 8	Video 9	When Necessary 4	Web-based System 10	Rural Hospital 9	
Transmit	Patient 32	Medical Information 24	At Completion of Previous Step 85	Internet 26	Home 28	
	Nurse 9	Medical Information and Images 13	N/A 5	Telephone 9	Hospital 20	
	Researcher 7	Video 9		Mobile network 6	Rural Hospital 11	
Retrieve	Specialist 13	Medical Information 27	As Soon as Possible 48	Computer 33	Specialist Office 30	
	Researcher 10	Medical Information and Images 11	When Necessary 22	Videoconferencing Equipment 18	Hospital 29	
	Doctor 9	Video 10	Scheduled Meeting 15	Web-based Server 9	Research Centre 8	
Diagnose	Specialist 17	Medical Information 20	At Completion of Previous Step 79	Experience 62	Specialist Office 39	
	Doctor 15	Symptoms 11	N/A 5	Pre-defined criteria 7	Hospital 24	
	Patient 10	Images 10	Scheduled meeting 4	Speech Exercises 5	N/A 8	
Package	Specialist 16	Diagnosis Report 24	At Completion of Previous Step 81	Videoconferencing System 23	Specialist Office 40	
	Doctor 13	Evaluation Report 17	N/A 7	Computer 19	Hospital 22	
	Patient 9	Final Report 15		Web-based System 12	N/A 13	
Transmit	Specialist 15	Final Report 22	At Completion of Previous Step 78	Internet 29	Specialist Office 37	
	Doctor 10	Diagnosis Report 21	N/A 8	N/A 9	Hospital 21	
	N/A 10	Evaluation Report 12	Weekly 1	Telephone 8	N/A 11	
Use	Patient 41	Diagnosis Report 20	After Completion of Previous Step 58	As Instructed 45	Home 37	
	Doctor 11	Information 14	When Necessary 14	Treat Patient 12	Hospital 13	
	Nurse 8	Evaluation Report 11	As Soon as Possible 12	Learn 11	Rural Hospital 13	

Table 4-2 is a summary of the telemedicine process for the articles documented during the study, after the data had been sorted in Microsoft Excel. Each block contains the top three most selected values for the given phase of the telemedicine process. The number next to each selection is the number of times the selection was made. The full set of results pertaining to the telemedicine process is represented graphically in Appendix G. Each graph shows the result for a single step in the telemedicine process and these are sorted, in terms of occurrence, from most to least. In total, there are 40 graphs representing the telemedicine process.

On closer inspection of Table 4-2, it becomes apparent that in most instances, when selecting the option for the “*When*” question, the most common occurrence is “*At completion of Previous Step*.” This is to be expected since the telemedicine process is based on a structured and tiered approach, meaning that the next step can usually only be initiated once the previous step is complete. This field can therefore be construed as a redundant field since the answer to the question is always the same. Alternatively, this question field could be converted to an auto

completion field, since in most of the other instances, where this option was not the preferred choice, this question was not applicable to the project in question.

A summary of the disease type, implementation layer, purpose of the project and medical specialisation collected during the study is shown in Table 4-3. Appendix G contains the complete information regarding these results which are shown graphically and sorted from most to least, in terms of occurrence.

Table 4-3: Top three results for disease, implementation layer, purpose and specialisation.

	Description	Count
Disease	No Specific Disease	16
	Cancer	8
	Stroke	6
Implementation Layer	Feasibility Test	16
	Pilot	15
	Observational Study	12
Purpose	Remote Consultation	17
	Self Management	11
	Provide Specialist Support	10
Specialisation	Cardiology	9
	Ophthalmology	8
	General Health	8

Table 4-3 indicates that most telemedicine projects do not focus on a specific disease. If this is the case, the aim of the project turns its focus to improving the efficiency of healthcare service delivery in an area. These projects also aim to assist healthcare workers in rural and remote locations by providing healthcare services and specialist support. According to the sample of telemedicine articles used during the study, cancer and stroke are the most common diseases addressed in telemedicine projects.

The top three categories in the implementation layer of the telemedicine projects are feasibility tests, pilot studies, and observation studies respectively. These categories all represent temporary projects, which is consistent with the current status of telemedicine as being a new application of technology to support healthcare. In the majority of telemedicine projects, the key deliverable is to test a certain technology and to verify its feasibility within the existing health service delivery framework of a specific location. One of the primary challenges for telemedicine, and proof of its sustainability as a viable solution to addressing healthcare issues, is the conversion of these temporary programmes into full-scale, long-term projects.

The purpose of a telemedicine service is to provide medical service over distance, as the name implies (see section 2.2), and to provide specialist support to healthcare workers in remote and rural areas. It is thus no surprise that the top categories describing the purpose of the telemedicine projects, documented during this study, are aligned in this way. The top three categories, indicated in Table 4-3, are to provide remote consultations, self-management support to patients and specialist support to medical staff in remote and rural locations.

The concept of remote consultation in rural areas is not exclusive to third world countries. The majority of the telemedicine projects, used for the purpose of this study, are from first world countries, as is illustrated by Figure 4-2. Data from the United Kingdom, the United States, and the Netherlands were used since the documentation of telemedicine projects is at a more advanced stage in these countries than is the case in their third world counterparts.

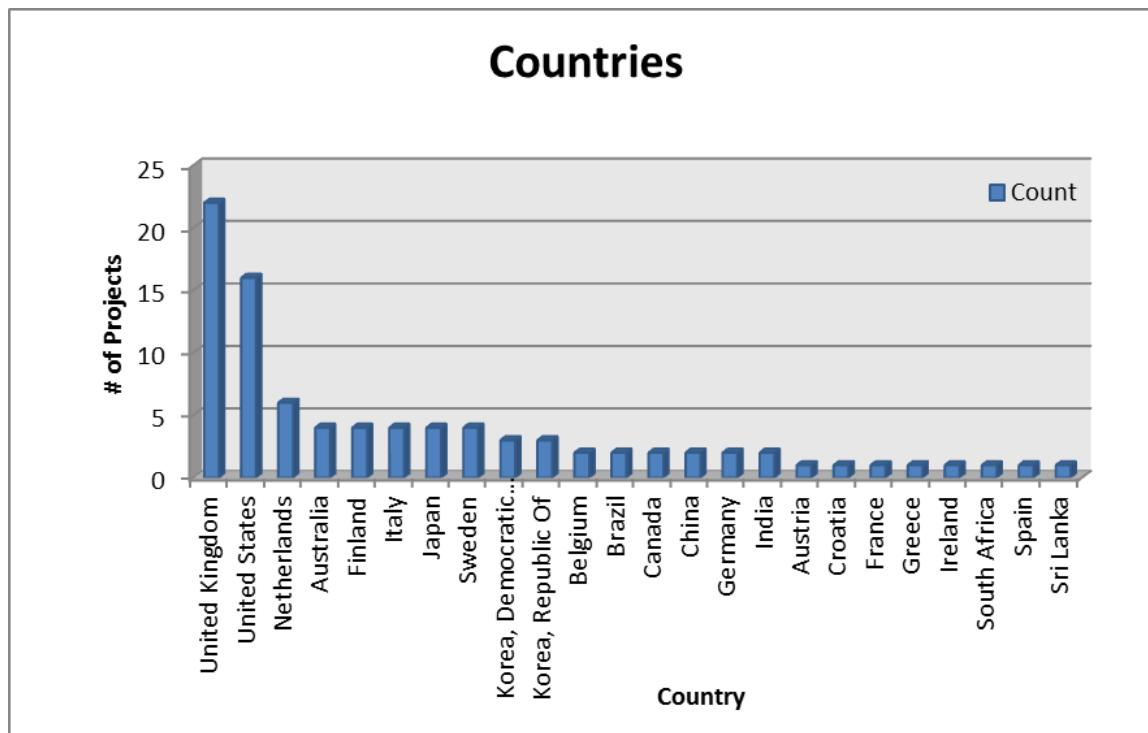


Figure 4-2: Number of telemedicine projects per country from the sample used in the alpha test.

The majority of the projects documented during the study did not state the specialisation of the project clearly. However, cardiology (disorders of the heart), ophthalmology (branch of medicine that deals with diseases of the eye), and general health were the most common specialisation categories for the projects documented during the study.

The next section discusses the relationship between the various stages and fields of the telemedicine process.

4.5 Relationship between Fields and Stages of the Telemedicine Process

The documentation of the telemedicine process, and the additional information concerning a telemedicine project, is in excess of 50 data fields. As a result, this can be time consuming and have a negative effect on the person responsible for collecting the data. For this reason, it is important to remove any redundant or irrelevant fields that may exist within the telemedicine process so as to reduce and streamline the amount of data which needs to be recorded.

In the identification of repetitive fields, a similarity relationship between the various fields has to be established. For example, the same person collects, packages, and transmits the information for a project and this occurs in multiple projects. To accomplish this, a table correlating all the different fields for each step of the telemedicine process (see Figure 4-1 on page 47), was established using Microsoft Excel.

Table 4-4: Field Relationship - "Who"

"Who"		Collect			Retrieve	Diagnose			Use
		Collect	Package	Transmit		Diagnose	Package	Transmit	
Collect	Collect	100%							
	Package	82%	100%						
	Transmit	77%	86%	100%					
Diagnose	Retrieve	9%	12%	14%	100%				
	Diagnose	8%	9%	11%	73%	100%			
	Package	12%	16%	13%	77%	87%	100%		
	Transmit	10%	12%	10%	76%	79%	79%	100%	
Use		63%	54%	53%	19%	9%	11%	9%	100%

The similarity results for the critical inquiry question “who” is shown in Table 4-4. It indicates the relationship between the fields for the people who are responsible for completing the respective steps in the telemedicine process. The values in the table indicate the percentage of times the two steps of the telemedicine process was undertaken by the same person. For example, for 87% of the project under investigation, the same person who performed the diagnosis also packaged the feedback, but only 11% of the people who transmitted the data, also performed the diagnosis.

The fields that are highlighted are instances where 70% or more of the projects indicated that the two relating fields were the same. As an example from Table 4-4, it can be seen that in 82% of the projects documented during the study, the person responsible for collecting the information was also responsible for packaging the information. Moreover, in 86% of the projects, the person responsible for packaging the information was also responsible for transmitting the information to its destination.

The results shown in Table 4-4 are not surprising as it is to be expected that the collection, packaging, and transmission of information are all done by the same person. It is similar to a person sending an e-mail: the same person would be responsible for collecting, attaching, and sending the information.

If only the “who” aspect of the critical inquiry is taken into consideration, it would likely make sense to simplify the telemedicine process. However, in the discussions that follow, it will become evident that it is necessary to describe the telemedicine process in the detail.

Table 4-5: Field Relationship - "What"

"What"		Collect			Retrieve	Diagnose			Use
		Collect	Package	Transmit		Diagnose	Package	Transmit	
Collect	Collect	100%							
	Package	69%	100%						
	Transmit	68%	91%	100%					
Diagnose	Retrieve	67%	83%	86%	100%				
	Diagnose	62%	70%	70%	71%	100%			
	Package	9%	12%	11%	12%	14%	100%		
	Transmit	8%	9%	9%	11%	12%	70%	100%	
	Use	1%	3%	2%	3%	1%	47%	59%	100%

Table 4-5 indicates the similarity, in terms of data collected, between the respective steps. As was the case in Table 4-4, the highlighted values indicate the fields that have a similarity percentage of more than 70%.

Table 4-6: Field Relationship - "When"

"When"		Collect			Retrieve	Diagnose			Use
		Collect	Package	Transmit		Diagnose	Package	Transmit	
Collect	Collect	100%							
	Package	3%	100%						
	Transmit	1%	92%	100%					
Retrieve		42%	3%	3%	100%				
Diagnose	Diagnose	4%	81%	84%	4%	100%			
	Package	1%	89%	89%	3%	91%	100%		
	Transmit	1%	83%	86%	4%	88%	93%	100%	
Use		9%	1%	0%	19%	1%	1%	2%	100%

Table 4-6 indicates the similarity between the respective steps in the telemedicine process, in terms of completion. “Process”, as a term, suggests that each step is executed systematically, implying that a step can only be completed once a previous step has been completed. Thus, the majority of the data values pertaining to the question “when” would be “*at completion of the previous step*”. For example, in order to transmit information using a computer, the data would have to be packaged in the appropriate format before being sent; hence it could only be transmitted on completion of the previous step. This finding was therefore a contributory factor as to why this table had such high similarity percentages.

The reason for the similarity figures being under 100% can be attributed to the exceptions, such as live video streaming, where transmission occurs without any user interaction. As in previously shown tables, the highlighted cells indicate the related fields where there is a similarity percentage of above 70%. It is interesting to note that all the highlighted fields in this table contain similarity percentages of over 80%.

Table 4-7: Field Relationship - "How"

"How"		Collect			Retrieve	Diagnose			Use
		Collect	Package	Transmit		Diagnose	Package	Transmit	
Collect	Collect	100%							
	Package	26%	100%						
	Transmit	7%	11%	100%					
Retrieve		21%	23%	12%	100%				
Diagnose	Diagnose	1%	1%	1%	2%	100%			
	Package	7%	42%	9%	27%	8%	100%		
	Transmit	6%	7%	61%	12%	8%	19%	100%	
Use		0%	0%	0%	2%	1%	3%	3%	100%

Table 4-7 indicates the similarity in the manner of completion between the respective steps within the telemedicine process. The “how” in this step refers to the technology employed in the telemedicine project, such as a computer or medical device, rather than to the method. None of the fields in the table indicate a high similarity percentage between the respective fields. This can be attributed to the fact that different types of technology are used in the various steps.

For example, information can be collected using a video camera, after which it is encoded/packaged using a computer and then transmitted via e-mail. The low similarity values, indicated in the table, strengthen the claim of the telemedicine process that this step must be considered in detail. Unlike in the previous tables, where possible reductions in the telemedicine process are indicated, in this instance, the “how” aspect of the critical inquiry seems to be an important aspect which must be included in all the steps of the telemedicine process.

Table 4-8: Field Relationship - "Where"

"Where"		Collect			Retrieve	Diagnose			Use
		Collect	Package	Transmit		Diagnose	Package	Transmit	
Collect	Collect	100%							
	Package	79%	100%						
	Transmit	82%	74%	100%					
Retrieve		13%	11%	17%	100%				
Diagnose	Diagnose	10%	8%	13%	79%	100%			
	Package	10%	10%	12%	74%	83%	100%		
	Transmit	10%	10%	12%	74%	81%	88%	100%	
Use		71%	59%	66%	20%	12%	9%	10%	100%

Table 4-8 shows the similarity between fields in terms of where the corresponding step of the telemedicine process is completed. As in the previous tables, the highlighted blocks show percentage values that exceed 70%. Note the 71% similarity between where the information is collected and where the information is used once the diagnosis step is completed. This is to be expected, since the place where the information is collected will, in the majority of cases, also be the place where the patient will be treated, as is indicated by the data.

Although the table indicates a high similarity between place of data collection and use, this information cannot be excluded or merged together. These two steps are part of the primary structure of the telemedicine process and must be associated with each project. In contrast to the primary fields, the sub-fields, such as the package and transmitting fields, which are included

in the telemedicine process to provide an extensive description of the project, can be altered or merged with one another if found to be unnecessary.

In order to reduce the number of fields required to document the telemedicine process, the fields that can be grouped together, have to be identified. Steps, such as ‘collect’, ‘retrieve’, ‘diagnose’, and ‘use’ are required to document the telemedicine process. The only means whereby the telemedicine process can be shortened is by grouping the ‘package’ and ‘transmit’ steps of the collection- and the ‘diagnosis’ phases together if the similarity between all three fields is high.

Tables 4 to 8 indicate the similarity percentage between two fields of the telemedicine process for all the fields. Table 4-9 is a summary of the similarity relation of the fields in the collection phase of the telemedicine process. This table includes an additional column identifying the percentage of the total number of projects that contain the same value for all three fields.

Table 4-9: Relationship summary of the collection phase

	Collection Phase			All Three
	Collect - Package	Package - Transmit	Collect - Transmit	
Who	82%	86%	77%	74%
What	69%	91%	68%	66%
When	3%	92%	1%	1%
How	26%	11%	7%	7%
Where	79%	74%	82%	70%

It is not possible to reduce the entire critical inquiry for a phase since, even though the same person could be responsible for accomplishing each of the collection phase tasks, different equipment is required to complete each task. An example of this would be when a patient collects images using a camera, packages the images using computer software and then transmits the data, using an internet connection. In all three instances, the person responsible, or the “who”, remains the same but the equipment required, the “how”, was different for each step.

Table 4-10: Relationship summary of the diagnosis phase

	Diagnosis Phase			All Three
	Diagnose - Package	Package - Transmit	Diagnos - Transmit	
Who	87%	79%	79%	76%
What	14%	70%	12%	12%
When	91%	93%	88%	87%
How	8%	19%	8%	7%
Where	83%	88%	81%	78%

Table 4-10, like Table 4-9, is a summary of the similarity percentages for the fields in the diagnosis phase of the telemedicine process. An additional column, indicating the percentage of the total number of projects where all three fields had identical values, has been added to the table.

Table 4-11: Original telemedicine process

	Steps applicable to context							
	Who	Collect	Cpackage	Ctransmit	Retrieve	Diagnose	Dpackage	Dtransmit
What	Collect	Cpackage	Ctransmit	Retrieve	Diagnose	Dpackage	Dtransmit	Use
When	Collect	Cpackage	Ctransmit	Retrieve	Diagnose	Dpackage	Dtransmit	Use
How	Collect	Cpackage	Ctransmit	Retrieve	Diagnose	Dpackage	Dtransmit	Use
Where	Collect	Cpackage	Ctransmit	Retrieve	Diagnose	Dpackage	Dtransmit	Use

Table 4-11 represents the telemedicine process in a tabular format. The highlighted cells indicate the two or three related fields where the respective fields were similar in more than 70% of the total number of projects documented during the study. After the reduction and merging of fields, advocated for those with a similarity percentage of more than 70%, the altered telemedicine process is shown in Table 4-12. Here one can see that the number of fields, required to document the telemedicine process for a telemedicine project, has been reduced to 27.

Table 4-12: Redefined telemedicine process

	Steps applicable to context							
	Who	Collect			Retrieve	Diagnose		
What	Collect	Cpackage		Retrieve	Diagnose	Dpackage		Use
When	Collect	Cpackage		Retrieve	Diagnose			Use
How	Collect	Cpackage	Ctransmit	Retrieve	Diagnose	Dpackage	Dtransmit	Use
Where	Collect			Retrieve	Diagnose			Use

This revised telemedicine process is used during the next phase of developing the information system to support the use of telemedicine in South Africa. The original telemedicine process data collection form will remain as part of the information system. This will allow additional articles describing telemedicine projects to be added to the database over time. If necessary, further analysis regarding the telemedicine process can then be conducted, incorporating the additional information.

4.6 Conclusion

In this chapter, a meta-study was performed to identify the nature of telemedicine. The telemedicine process was defined to serve as a structured approach to documenting information on telemedicine projects. Additional information about the various telemedicine projects was also stored in the database. Literature from the *Journal of Telemedicine and Telecare* was used to obtain empirical data, using both the telemedicine process and the additional information fields to document the telemedicine projects.

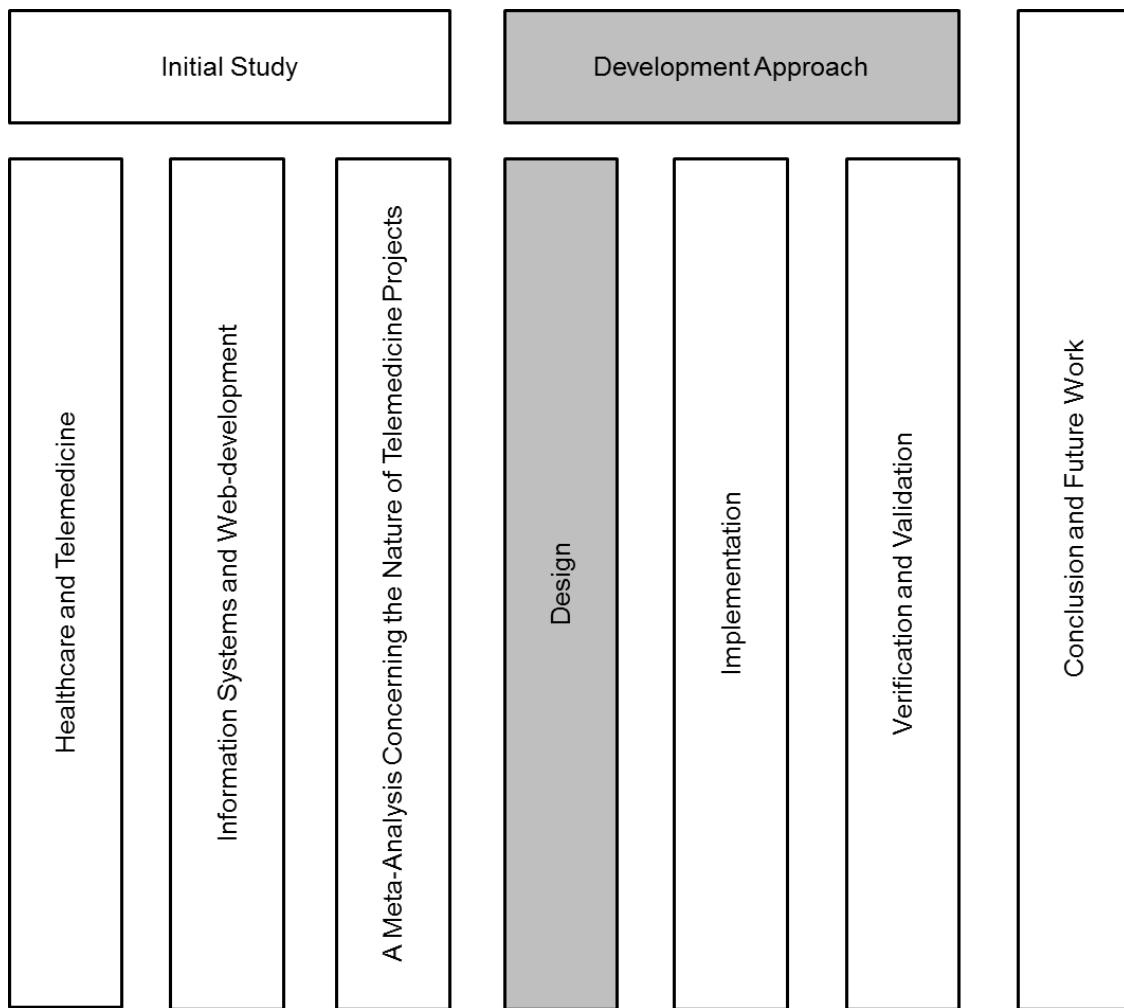
After the identification of the required articles from the *Journal of Telemedicine and Telecare*, a three-day data study was undertaken to document the articles that describe the telemedicine projects. This study was performed by three students from Stellenbosch University in a monitored and controlled environment.

The results obtained from the study were explained and the most common findings discussed. It was also mentioned that some of the telemedicine process fields were very similar and therefore provided the same information. An analysis was thus performed on the similarity of these fields and a subsequent revised version of the telemedicine process was then proposed.

The next chapter discusses the design of the information system. This includes the database and interface which were used during the meta-study in this chapter. Design changes and recommendations identified during the meta-study, are also included in the next chapter.

5. Design

In this chapter, the design and development of the information system that could be used to support telemedicine in South Africa is discussed. This includes the development of the back-end (database structure) and the front-end (interface) of the information system. Features, that allow the users of the system to retrieve and view the information stored in the database, are also taken into consideration. In addition, challenges that arose during the design phase are also discussed in this chapter.



5.1 Top-down Design Approach

A top-down design approach (also known as a stepwise design approach) was followed to identify the various sub-systems and components that needed to be developed. A top-down design approach is visualised by first viewing the system in its entirety and then breaking it down into smaller parts or sub-systems. Using a top-down design approach allows a systems analyst to firstly identify the overall objectives of a system, as well as to ascertain how they would best be met. As a second step, an analyst would then divide the identified systems into sub-systems [9].

The top-down design method is compatible with the Systems Development Life Cycle (SDLC) approach, discussed in Chapter 1. This approach attempts to avoid the chaos of designing the entire information system all at once [9]. Figure 5-1 shows the break-down of the larger components of the information system into the sub-systems.

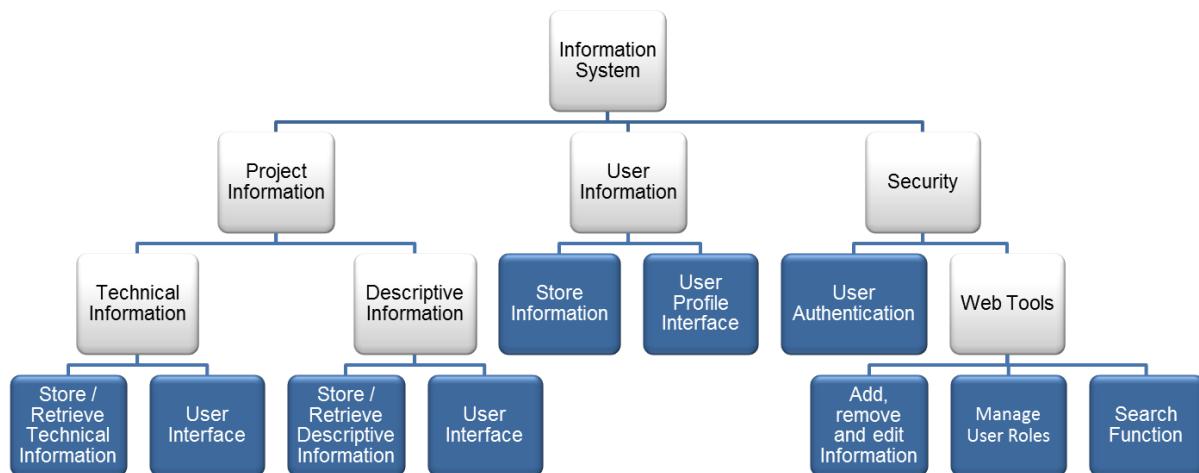


Figure 5-1: Breakdown of system into sub-systems and components

Each of the components at the end of every branch of the hierarchy is called a fundamental sub-system. All of these sub-systems have to be designed, developed and integrated with one another for the information system to function properly. Each of the final components can be allocated either to the front-end (user interface) or back-end (database and data structure) development of the information system. In some instances, such as user authentication, the sub-system will feature in both the front-end and back-end development.

5.2 Developing the Back-end of the Information System

It is important to know and understand the capabilities of the software that is utilised when developing an information system. Using software that enables compatibility between the various components will aid the development process.

Initially, Microsoft SQL Server 2008 was identified to develop the back-end of the information system. However, due to limitations on the server made available for the project (Stellenbosch University hosting server), Microsoft Access 2007 is now used for the development of the database structure of the information system.

The server provided by the University of Stellenbosch did not allow the ASP.NET framework and the SQL Server database structure to run on the same server. Instead, the ASP.NET framework had to be hosted on the Windows server and the SQL database on the Linux server. This is because Linux provides a safer environment for database hosting and most developers use PHP code (general-purpose server-side scripting) to interact with the database. It is possible to configure the ASP.NET framework to interact with the SQL database running on the Linux server by building a connection between the database and the server, but Microsoft provides an alternative for the SQL database structure in the form of an Access database structure.

Although the information system will be moved to a new location, still to be determined by the Medical Research Council, after completion, it has been agreed that the Microsoft Access database structure will be used for development and operation of the information system. The Microsoft Access database structure is capable of handling the required amount of data for documenting projects and maintaining user information. It is also possible, if future developments of the information system require it, to switch to a SQL database structure by using Microsoft Access's built-in database converter.

The method for converting the default SQL database to a Microsoft Access database for the ASP.NET framework is documented by Imar Spaanjaars on the website ImarSpanjaars.com [50]. The Microsoft Access database is then created automatically to manage user roles and login information when a new project is created with Microsoft Visual Web Developer. Furthermore, Microsoft provides the Microsoft Access database on their support website. This database replaces the existing SQL database. A new project can then be created with Microsoft Visual Web Developer, selecting the Microsoft Access database as the default role provider structure.

The existing web pages, created before the conversion to the Microsoft Access database structure, are then manually duplicated in the new project location and the references to the database are changed to the new Microsoft Access database. All the features, such as user authentication, password recovery, and user roles are kept intact with the Microsoft Access role provider database.

It is important to note that at this stage of development, only the default database containing the standard role providers and user registration features have been created. The database diagram for the role provider database can be viewed in Appendix C. It must be noted that the custom user information table (custom_UserInfo) is added manually to the default database created by Visual Web Developer. This allows the information system to capture and store additional information about a user during the registration period. The next section discusses the development of the database required for telemedicine project information storage and management.

5.2.1 The Telemedicine Process Database

The first phase of the database development focuses on the telemedicine process, used during the meta-study, as discussed in the previous chapter. This includes the 40 fields required for the critical inquiry, shown in Table 5-1, and the 12 project-specific information fields, shown in Table 5-2.

Table 5-1: Tabular representation of the telemedicine process

	Critical Inquiry				
	Who	What	When	How	Where
Telemedicine Process	Collect				
	Package				
	Transmit				
	Retrieve				
	Diagnose				
	Package				
	Transmit				
	Use/Retrieve				

Table 5-2: Additional information collected about telemedicine projects

Project Specific Information Fields

Article Number	Country
Project Name	Implementation Layer
Author	Purpose
Outcome	Disease
Journal	Specialisation
Volume	User uploading project

The database is structured in such a manner that the user responsible for completing the telemedicine process documentation form primarily uses drop down lists to populate the database. To incorporate the drop down lists, additional tables need to be created for each category that uses a drop down list to populate a field in the telemedicine project collection form. Creating separate tables to provide the drop down lists with selection items enables the creation of additional forms, allowing users to add customised content to the drop down list fields. Figure 5-2 is an extract of the database structure created in Microsoft Access for the telemedicine process.

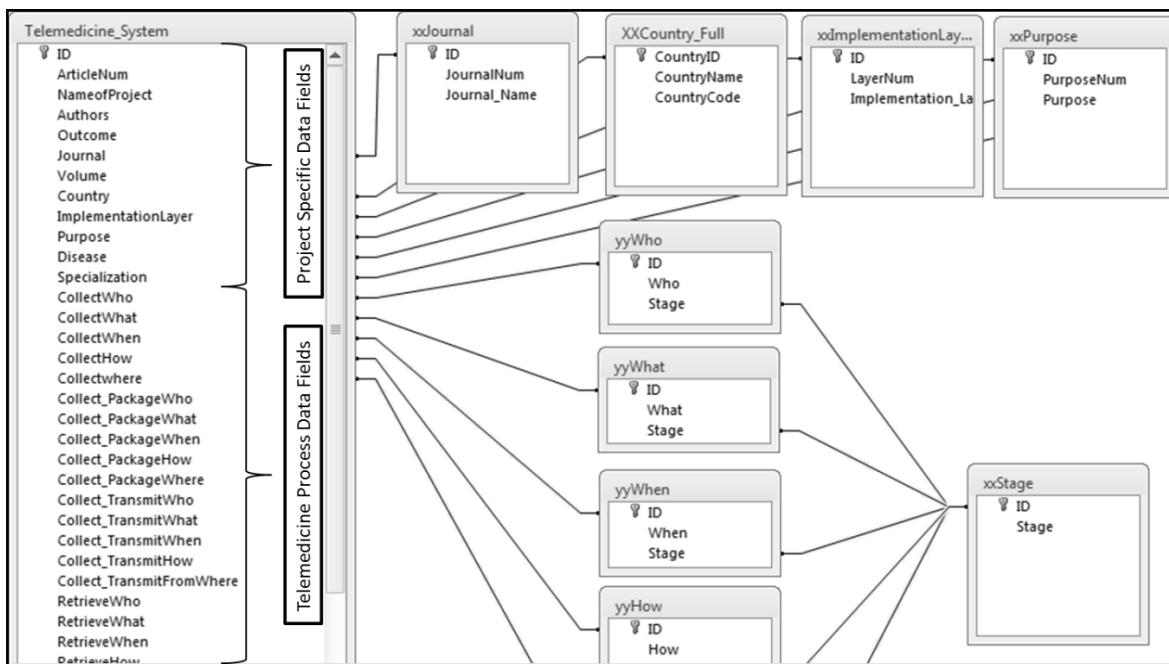


Figure 5-2: Extract from telemedicine process database (Screenshot, Microsoft Access 2007)

The above figure illustrates the separate tables created for each of the drop down list fields in the main table. Creating separate tables for the drop down lists improves the manageability of future administrators of the system, allowing them to add content to drop down lists from the user interface, rather than manually adding the selection options in the code behind the

information system. This also allows administrators and/or users of the information system to remove moving values from drop down lists. The figure also indicates the separate demarcations between the project specific data fields and the telemedicine process data fields. Appendix C gives details of the completion of the telemedicine process database diagram, as exported from Microsoft Access.

A benefit of using drop down lists to populate the database is the uniformity of the data that is stored in the database. This reduces the possibility of user errors when recording information pertaining to the telemedicine process. The drop down list fields also serve as a filter parameter when searching for projects in the database. The ability to retrieve stored projects, based on certain parameters, is discussed during the development of the front-end of the information system in section 5.3.

5.2.2 The Additional Project Information Database

The Medical Research Council requires additional information pertaining to telemedicine projects in South Africa. This includes information such as the person responsible for the project, the aim of the project and milestones that need to be achieved. See Appendix E for the full list of the required information.

Figure 5-3 is an extract of the table created in Microsoft Access and which is responsible for the storage of the additional information required by the Medical Research Council. The majority of the fields in this table are free-text fields, allowing users to enter multiple lines of text into the table. The only field that contains a drop down list is where the province of the project needs to be specified. Unlike the table created for the telemedicine process, all the fields required to populate this table are not compulsory. This is because the required information for a given project is not always available. However, the Medical Research Council requires the user responsible for uploading the information to the system to provide as much information as they can.

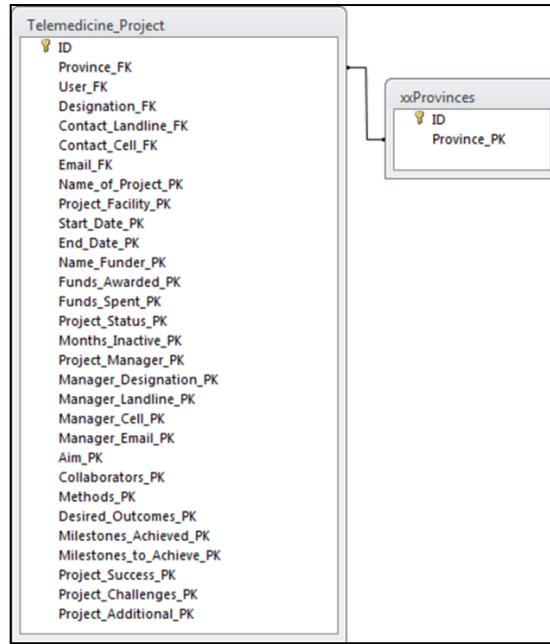


Figure 5-3: Extract from additional info for telemedicine project database (Screenshot, Microsoft Access 2007)

Although users do not have to complete all the requested information fields, they can add to or edit information at a later stage, since the project will be linked to their profile. This is part of the front-end development of the information system which is discussed in section 5.3. The table shown in Figure 5-3 will be used, together with the revised telemedicine process table, which will be discussed in the next section, to document telemedicine projects in South Africa.

5.2.3 The Revised Telemedicine Process Database

The initial database structure for the telemedicine portion of the information system included only the telemedicine process and its relevant table (Figure 5-2), used during the meta-study. After the analysis of the empirical data collected during the meta-study, a revised version of the telemedicine is proposed (see section 4.5).

The revised database for the telemedicine process, included in the information system, is shown in Figure 5-4. It is similar in design to the previous database and also utilises drop down lists to populate the main user form. However, the feature, used to store information and entered into the database as values, which was included in the table used for the meta-study, has been removed. This is so that the data exported to Microsoft Excel can be examined analytically. Thus, for further iterations of the information system, this feature is not required and is

therefore omitted from the design of the respective tables forming part of the telemedicine process. The information stored in the respective tables can be visualised using the web-interface rather than having to export the data to Microsoft Excel in order to see it.

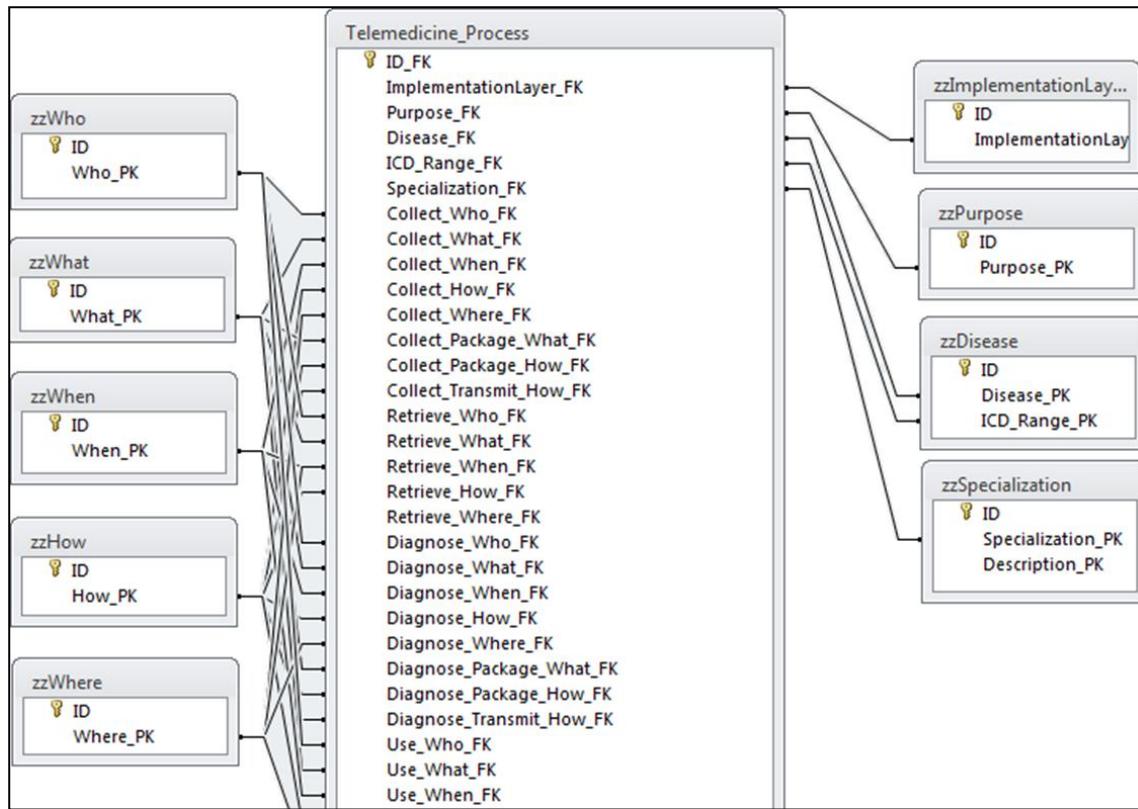


Figure 5-4: Revised database for the telemedicine process (Screenshot, Microsoft Access 2007)

This version of the telemedicine process requires fewer fields to document the telemedicine project, thus requiring fewer relationships between the tables. After the development of the database structure, a draft form is created using Microsoft Access to test the integrity and robustness of the database. This allows problems to be identified and corrected before the interface is created. The complete database diagram, showing both the additional project information requested by the Medical Research Council and the revised telemedicine process, can be viewed in Appendix C.

5.2.4 Additional Database Functionality

The main purpose of the information system is to gather, manage, store and retrieve information concerning telemedicine projects in South Africa. However, the development of the

information system also provides an opportunity to expand the capabilities of the system to include additional features that can contribute towards improved healthcare practices.

The International Classification of Diseases (ICD) is the international standard diagnostic classification for all general epidemiology, a number of healthcare management purposes and clinical use. The latter includes an analysis of the general health situation of population groups. In addition, it involves monitoring the incidence and prevalence of diseases, and other health problems, in relation to other variables such as the characteristics and circumstances of the individuals affected, reimbursement, resource allocation, quality and guidelines. It is used to classify diseases and other health problems recorded on many types of health and vital records, including death certificates and health records. In addition to enabling the storage and retrieval of diagnostic information for clinical, epidemiological and quality purposes, these records also provide the basis for the compilation of national mortality and morbidity statistics by WHO Member States [38].

To assist administrative staff, it is possible to develop an ICD database search application using database queries. An electronic version of the ICD database, provided by the WHO on their website, was used to allow users to classify certain diseases at various stages using pre-defined drop down lists. The ICD code is returned from the database after the user has made the selections. Figure 5-5 shows a form, developed using Microsoft Access. The ICD search application is included in the information system and serves as an example of how information systems can assist people in the medical field. Similar systems for other tasks can also be developed.

Determine the ICD 10 CODE of a Specific Disease	
Disease Classification	Pregnancy, childbirth and the puerperium
Chapter	15
General Disease Description	Delivery
Specific Disease Description	Multiple delivery
GET ICD 10 CODE	
ICD 10 Code Without Dot	O84
ICD 10 Code Without Asterisks	O84
ICD 10 Code Without Dagger	O84.-
Place in Classification Tree	N
Type of Terminal Node	X

Figure 5-5: ICD code calculator (Screenshot, Microsoft Access 2007)

5.3 Developing the Front-end of the Information System

Microsoft Visual Web Developer Express 2010 was used to develop the front-end of the information system. The ASP.NET framework was developed and marketed by Microsoft to allow programmers to build dynamic websites, web applications and web services to be used as template for the front-end development of the information system. This template includes the database structure shown in Appendix C, allowing role providers and user authentication to be added to the information system. This is an important security feature and ensures that the data in the information system is protected. It also allows administrators of the information system to create user roles and user permissions to restrict the access of users to certain parts of the information system.

In addition to Microsoft's Visual Web Developer, Adobe's Dreamweaver CS5 is used in the front-end development of the information system. Dreamweaver provides more creative features with regards to website development and design than Microsoft's Visual Web Developer. The Visual Web Developer is used to create the structure, layout and database features of the information system and Dreamweaver to refine visual aspects of the information system and synchronise the information system files between the developer computer and the hosting server.

5.3.1 Creating the Project

To initiate the building process for the information system (connecting the front-end with the back-end), a new project was created in Visual Web Developer using the ASP.NET 4.0 template. The file structure is automatically generated within a folder. This includes folders to store the databases, images, style sheets, and various script files (used to include advanced website features). The default interface and style was converted to match the colours and structure of the Medical Research Council's preferences using a cascading style sheet (CSS).

The web page file structure used for the purpose of the information system in this project has an “.aspx” extension. The “x” at the end of the file extension indicates that either C# or VB code is used in conjunction with the standard active server page commands. The C# or VB code is stored in a separate file and is linked to the “.aspx” page by including a command string at the top of the “.aspx” page. The majority of the code used in the development of the information system in this project is VB code, but certain features, such as utilising the Microsoft Access role provider database, was done using C# code.

5.3.2 Incorporating the Role Provider Feature and User Profile Page

The role provider feature, provided by the ASP.Net 4.0, creates a SQL database by default. Due to the restrictions on the server, made available for the purpose of this project, the role provider database was converted to Microsoft Access (see section 5.2).

This feature is a necessary component of the information system because certain information which is collected is private and contains the contact details of users. It also only allows users who have been granted access to upload telemedicine project information onto the system. The uploaded information is connected to their account, allowing the collection of information to be monitored. It also deters users from misusing the information system by randomly uploading information to the database. Figure 5-6 shows the user profile page.

The screenshot shows a user profile page titled 'WEBMASTER 'S PROFILE'. At the top left is a placeholder for a profile picture with the text 'Edit/Upload Image'. Below it is a table with personal information:

Title	Mr
First Name	Alwyn
Last Name	Van Zyl
Profession	Masters Student
Institution	Stellenbosch University
Member ID	56

Below the table are two buttons: 'Edit' and '[Change Password]'. The main content area is titled 'My Projects:' and contains a table of 22 projects:

ID	Name of Project	Province	Status	Action
1	Information System for Telemedicine in South Africa	Western Cape	Active	To Project
5	Good Start III ("Saving Newborn Lives")	KwaZulu-Natal	Active	To Project
10	Philani Mentor Mothers Project	Western Cape	Active	To Project
11	SIMPILL	Western Cape	Active	To Project
12	A Mobile Alternative to ACASI	KwaZulu-Natal	Active	To Project
13	Young Africa Live	Gauteng	Active	To Project
19	Encouraging HIV testing through SMS	Western Cape	Active	To Project
20	Using SMSs to reduce loss to follow-up in PMTCT	Western Cape	Active	To Project
21	Using SMSs for Adherence to ARVs	Western Cape	Active	To Project
22	Using SMSs to improve retention in care of people on ARVs	Western Cape	Active	To Project

At the bottom of the table are navigation links '1 2'.

Figure 5-6: User profile page showing personal- and project details (Screenshot, 2012)

The profile page is a summary of the user's information: it includes details of all the projects and articles that the user has uploaded to the information system. The user can edit personal information on the profile page or navigate to a specific project and edit the information pertaining to the selected project. This ensures that details about both the user and the project are up to date on the system.

5.3.3 Connecting the Databases and Creating Forms

The drag-and-drop feature of Microsoft Visual Web Developer was used to connect the databases to the various web pages (see section 3.2.2). A user form was developed to allow a user to add information directly to the database so as to populate each of the tables in the database. This was compiled using the drop down lists from the telemedicine process collection form used during the meta-study.

The default form created by Microsoft Visual Web Developer contains only text box fields and requires additional customisation to create a professional looking layout. In order to do this, drop down lists have to be added and connected to the database manually. Since the automatic style options provide only limited customisation options and are often insufficient, options were

specially designed (see Appendix D) and incorporated for the telemedicine process information collection form.

The two fields, article number and user who uploads the information, are automatically populated onto the form using VB code. The user cannot edit this information and the article number is only for display purposes. This feature is removed after the meta-study (discussed in section 5.4.2.). The user name of the person responsible for uploading the information is added to the database and is used to link the user with the project, which is reflected on the user's profile page. Creating this link provides users with control regarding the projects that they upload.

The form used to collect the descriptive information requires fewer drop down lists than that of the telemedicine process form. It does, however, require free text fields, which allow users to enter customised information. Nevertheless, the same method is used to create both forms. The appropriate text boxes are added to the descriptive information form and connected to the database. The text areas that require a larger amount of input from the user are converted to multi-line text fields. The form is included in Appendix D.

The fields for collecting information about the user, as well as the designation and e-mail address of the user, are automatically entered into the form using VB code. This is done because the user information would already have been stored in the database when the user registered. Other contact information, such as phone numbers and address, are optional.

The above-mentioned forms are the main forms for the collection of data. The other forms, or versions of the form, are those that contain information pertaining to the telemedicine process and the necessary descriptive information. If a user wants to edit the project information at a later stage, the same form is used and the edit option selected.

5.3.4 Displaying the Projects on a Map

An additional table was created to store map coordinates which could be used during the documentation process of a telemedicine project. The table is able to store the latitude and longitude, along with the ID, of a project. The latitude and longitude is obtained by incorporating the Google Maps API (a web mapping service application and technology provided by Google to embed the Google map onto a web page) into the information system. A Google map, centred on South Africa, was added to the project documentation process.

After users completed the telemedicine project forms, they were directed to the web page containing the Google map. A marker on the map allows a user to specify the location of the telemedicine project by dragging the marker. The coordinates of the location specified by the user was then retrieved and stored in two text fields. Once the user was satisfied with the project location, a click would ensure that the latitude and longitude were stored in the table.

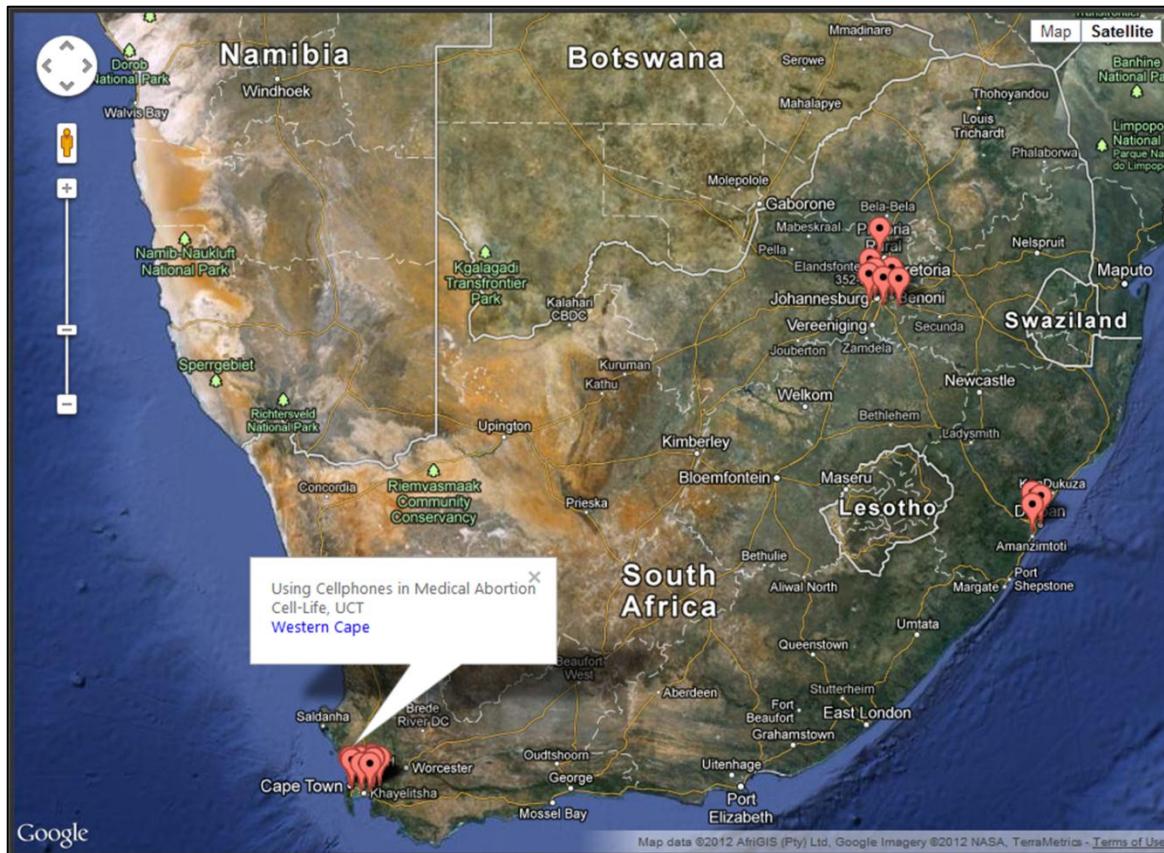


Figure 5-7: Telemedicine projects displayed on a Google map (Screenshot, 2012)

Figure 5-7 shows the telemedicine projects stored in the database on a Google map. A combination of Java and VB were used to retrieve the information and project coordinates from the database and then display it. If a user clicked on a project icon, a short summary, including the name of the project, the collaborators involved in the project and the province of the project, were displayed.

5.3.5 Searching the Database

After information has been collected and stored in the database, other users are able to retrieve it from the database by means of two methods, which are incorporated into the information

system. The first method provides the user with a list of all the projects, summarised in a grid view. The user then selects the desired project and is redirected to a page providing a detailed view of the selected project.

The second method allows the user to filter the data returned by the information system. This occurs by using the drop down list of fields located on the project registration form. Fields are used because the information is uniform and can be filtered using the same drop down lists as were used during the documentation of the project.

The screenshot shows a web-based application interface titled 'BROWSE PROJECTS'. On the left is a 'NAVIGATION PANEL' with a tree-view menu:

- Manage Users
 - User Overview
 - Manage User Roles
 - Add New User
 - Add Info to User
 - Remove Users
- Manage Database
 - Remove Article
- Manage Projects
 - Browse Projects

The main area is titled 'Search for Projects' and contains the following search parameters:

Province:	Project Status:	Projects Matching Search Parameters
KwaZulu-Natal	Active	3
<input type="button" value="Find"/> <input type="button" value="Reset"/>		

A table displays the results of the search:

Project Name	Province	Status	View
A Mobile Alternative to ACASI	KwaZulu-Natal	Active	Details
mobile health (smart phone and Google map) to support tuberculosis intensive case finding Ethekwini district	KwaZulu-Natal	Active	Details
Good Start III ("Saving Newborn Lives")	KwaZulu-Natal	Active	Details

Figure 5-8: Browsing the project database using the province drop down list as a filter (Website Screenshot, 2012)

Figure 5-8 illustrates how the information in the database is filtered. It uses the province and the status of the project to filter the information. Once a user has made the appropriate selections, the “Find” button is clicked and the VB code binds the returned information to the grid view. A counter has also been added to show how many of the projects in the information system match the search criteria.

5.3.6 ICD Database Search Application

A user interface, similar to the Microsoft Access interface (see Figure 5-5), has to be created if users are to be allowed access to the International Classification of Diseases (ICD) search application, discussed in section 5.2.4. In Microsoft Access, the filtering of the drop down lists occurred automatically because of features provided by Microsoft Access. To achieve a similar

filtering functionality in Microsoft Visual Web Developer, the coding had to be done manually. A combination of database queries using SQL and VB code running in the background was used to accomplish the filtering.

Figure 5-9 shows the ICD search application used in the information system. Although both Microsoft Access and Visual Web Developer provide the same database search functionality, the method for obtaining the correct output from the ICD database differs.

Prior to activating the search application, the user has to specify the classification of the disease. The drop down list available to the user is populated by using the table in the database which contains the chapter headings for the ICD codes, provided by the World Health Organisation (WHO). Once the user has selected a disease classification, the next drop down list field, the general disease description, is populated using the corresponding general disease descriptions found in that specific chapter of the ICD codes, provided by the WHO.

Having selected the appropriate disease description, the final drop down list field is populated with specific disease descriptions found in the selected sub-section of the general disease description. The final step is for the user to select the appropriate disease for which a code must be obtained. Once selected, the user selects the option to get the code from the database. The code ID for the specific disease is then returned from the database and displayed in a grid view. This includes the different coding structures for the disease.

The screenshot shows a web-based application for calculating ICD-10 codes. On the left is a navigation panel with links to 'ICD 10', 'About ICD', and 'ICD Calculator'. Below it is a 'COUNTDOWN TO ICD-10' timer showing 459 days, 11 hours, 3 minutes, and 14 seconds. The main area is titled 'ICD 10 CODE CALCULATOR' and contains three dropdown menus under 'STEP 1': 'CLASSIFICATION' (Certain conditions originating in the perinatal period), 'GENERAL DISEASE DESCRIPTION' (Birth trauma), and 'SPECIFIC DISEASE DESCRIPTION' (Birth injuries to other parts of peripheral nervous system). Below this is 'STEP 2' with buttons for 'Get Code' and 'Reset'. A table shows the search results: ID 6993, Disease Birth injuries to other parts of peripheral nervous system, Without Dagger P14.8, Without Asteriks P14.8, and Without Dot P148. At the bottom, there's a message 'If you found the calculator useful, please like it.' with a Facebook 'Like' button and a small figure holding a calculator.

Figure 5-9: The ICD database search application (Website Screenshot, 2012)

5.4 Challenges during the Development of the Information System

Technical and software issues determined and shaped the final design of the information system during its development. In certain instances, these issues required that the information system be adapted. Although the issues required adjustments to be made to the design of the information system, the structure of the information system did not change. The majority of the issues identified related to the implementation of the system and the accompanying design requirements for the end user of the information system.

5.4.1 Server Limitations

The server, used for hosting the website allows ASP (active server page script) and PHP script (server-side language to produce dynamic web pages) to be run, but does not support the SQL database to be hosted on the same server. The APS.NET web template automatically generates a SQL database to store the user information when a new project is created. This database integrates with the entire information system and is crucial to its functioning properly. Since the server does not support the structured query language required by the SQL database and Microsoft Visual Web Developer does not have a built in function that gives the developer the option to use a Microsoft Access database instead, it has to be converted manually. After the conversion, the standard role provider functions can be used. See section 5.2 for the discussion pertaining to the conversion of the role providers from a SQL database to a Microsoft Access database.

Another drawback of the server is that it is not compatible with the latest version of the Microsoft Access database structure (this is a common problem with most hosting servers). The latest version of Microsoft Access creates a database file with an “.accdb” extension and the server is only compatible with “.mdb” extensions. Access can, however, convert the newer database format to the older database format, allowing compatibility with servers not capable of running the latest format of the database. A problem with converting the database to an older format is that it only converts the tables, resulting in a loss of all the queries and forms. This is, however, not insurmountable since the forms have to be re-created in Visual Web Developer to be compatible with a web interface.

5.4.2 Refreshing Form Fields

The drop down list fields on the telemedicine process form (see section 5.2.1) require information found in the literature and users can add information using additional input forms which are created to populate the tables for the drop down lists. The fields populated using the additional forms include the type of disease, the implementation layer, and the purpose of the project. The collecting of the information is done during the meta-study and was discussed in Chapter 4.

The form gives users an opportunity to add information to the drop down lists if they found that the options in the drop down list were insufficient. However, because of problems surrounding

the addition of information using another form on another page of the information system, the drop down list of the main form had to be refreshed in order to include the new data. The entire form can be refreshed by reloading the page containing the main form, which includes the added information in the drop down list. However, this means the whole form is reset to its default state and the current progress of the project documentation is therefore lost. Considering that the form consists of 52 user entry fields, this is a most unwanted outcome.

A solution to this problem is to use the AJAX extensions (a group of interrelated web development techniques used on the client-side to create asynchronous web applications) provided by Visual Web Developer. The AJAX update panel, used in conjunction with VB code, is capable of upgrading only a portion of the form. For this reason, an AJAX panel is included near each of the drop down lists with the VB code, necessary for the triggering of the update process, placed in a button next to each drop down list.

This enables a user to select the refresh option, updating only the selected drop down list. This method allows the contents of the drop down list to be updated without resetting the entire form. Appendix D illustrates the telemedicine process collection form with the refresh buttons next to the drop down lists.

5.4.3 Rebuilding the Site Administration Tool

The ASP.NET template, used for the development of the information system, includes a site administration tool that allows the developer to add and assign user roles such as member, full member or visitor. The developer can also use the administrator tool to manage user information, monitor password security and assist users with password recovery. This is an effective tool that allows the developer to manage the technical aspects of the system. However, the site administration tool is not transferred to the server once the information system is hosted. It is only available on the developer computer during the development of the information system.

If administrators of the information system are to be allowed the same features as the developer, the site administration tool has to be incorporated into the design of the information system as web pages. These pages allow the administrator to add, edit and remove users from the information system and only users who are granted the appropriate access, can use them. Users can also be assigned different roles which give them access only to certain parts of the

information system. An administrator can also add, edit and remove information. The administrative web pages that are included in the information system are:

- Manage user roles
- Add new user to the database
- Add custom user information to the database
- Remove a user from the database
- Remove articles and projects from the database
- Edit information about telemedicine projects

The administrative pages are created using standard “.aspx” web pages. These are connected to the information system database and contain specific information. VB code is used to handle the user role feature. All the administrative pages are included under the “Manage” tab on the website.

5.5 Conclusion

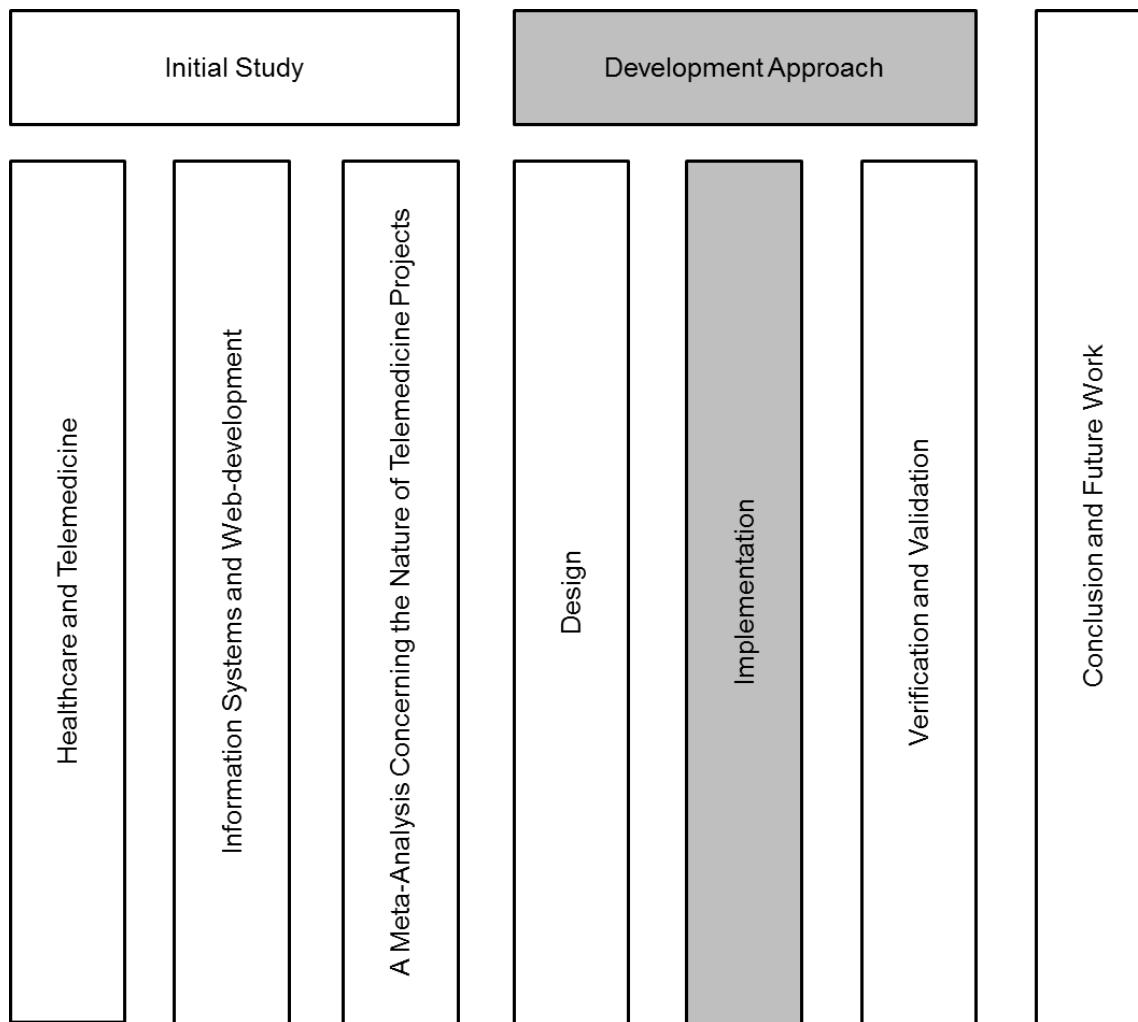
In this chapter, the design and development of the information system was discussed. The telemedicine process was defined to serve as a platform to collect relevant information pertaining to telemedicine projects. The top-down design approach, which breaks down the requirements of the information system to basic components, was followed for the development of the information system. These components were completed individually and then integrated to create a functioning information system.

The database that handles and manages the information, as well as the conversion of the database to a Microsoft Access database was discussed. After the completion of the back-end of the information system, the visual aspects of the information system were addressed. User forms and management tools were created to collect and manage the information within the system. The development of the ICD search application was also discussed.

Challenges, encountered during the design and development of the information system, were mentioned, specifically in light of server limitations which impacted on the implementation and design of the system. The re-construction of the administration tool, to allow the information system to be managed by a web master, was also an important aspect in the design of the information system, since this reduces the complexities of managing an information system.

6. Implementation

This chapter focuses on the implementation of the information system, and also looks at relevant literature. A method for the successful implementation of a telemedicine system and the pitfalls to avoid while doing so is included in the discussion. The impact that technology, acceptance, finance, the organisation, and policy have on a project is also considered.



6.1 Determinants of Successful Telemedicine Implementations

Telemedicine projects often remain in the pilot phase and do not reach the level of a sustainable project. A contributing factor is the lack of documented research and literature, useful in determining the feasibility of a proposed telemedicine project. The lack of post-implementation support and operation frameworks also contribute to the lack of sustainable telemedicine projects [51].

The information system developed in this study is not a telemedicine system (according to the definition provided in section 2.2), but is instead a support tool for telemedicine projects in South Africa and thus falls outside the scope of e-Health but in the scope of telemedicine. The implementation barriers, which the information system faces during implementation and operation, are similar to those faced by other telemedicine projects. The environment in which the information system is implemented is the same, including the stake holders and role players involved with telemedicine in South Africa.

Berg [52] showed in a study that more than 75% of telemedicine initiatives fail during the operational phase. To ensure the successful implementation and operation of the information system, key factors to succeed are identified and incorporated during implementation. Possible pitfalls and barriers that can influence the implementation of the information system are also identified and addressed. For the purpose of this study and the rest of the chapter, ‘implementation’ is defined as putting an idea or a concept into actual practice [53].

6.2 Determinant Classification for Successful Implementation of Future Projects

Broens [51] performed a quantitative literature review and identified five major areas that influence the success of a telemedicine project. These five areas are:

- **Technology** – support, training and usability;
- **Acceptance** – attitude and usability, diffusion and dissemination;
- **Financing** – provider and structure;
- **Organization** – intramural and extramural work practices;
- **Policy and legislation** – privacy, terms of use, standardisation and security.

The areas that influence the success of a telemedicine project, also impact the successful implementation of the information system developed in this thesis. The next few sections discuss these areas.

6.2.1 Technology

The review performed by Broens indicated the lack of user support as a major issue for technological acceptance. This includes support during the deployment and operation phase [51]. The support shown should not only include technical support on how to install and maintain the system, but also include methods to deal with errors and problematic situations.

Without the appropriate support, problematic situations and errors during the use of the system could lead to de-motivation and a high probability of abandonment of the system [54]. It is thus important to include and establish a functioning support framework within the information system. This will reduce the likelihood of abandonment of the information system, if a problematic situation arises.

Another requirement for the implementation of a new system is training. Generally, the people responsible for managing and operating the new system are not familiar with how it works. The research performed by Broens indicated that it is important to train users on how to use the newly implemented system. It is important that the training is not limited to the people directly responsible for the system only. The training must include all the people identified as stakeholders in the project, including managers and staff at the organisation [51].

The implication is that the appropriate training must be done once the information system is transferred to the Medical Research Council. This will ensure that the correct operational and maintenance procedures are performed. The training includes external courses in the field of information system design, web development and web management. This will allow the Medical Research Council to manage and expand the information system with the participation of its existing staff. The Medical Research Council will be responsible for identifying and sending the appropriate staff members on the required courses. The personnel, who are not sent on these courses but are also involved in the project, are trained to operate and perform the basic administrative tasks, associated with the information system. This will be done in a one day session after the transferral of the information system to the Medical Research Council.

6.2.2 Acceptance

Broens found that the acceptance of new technology is considerably influenced by the attitude and perception of the people affected by the project [51]. It is thus important to include all the people who are going to be impacted by the project in the requirement analysis and the design of the information system. This includes encouraging the Medical Research Council to incorporate their specific design requirements into the information system. Input and suggestions by professionals in the field of telemedicine are also taken into consideration during the design and development of the information system.

These requirements and inputs, obtained from telemedicine stakeholders, telemedicine workshops, telemedicine conferences, and the Medical Research Council are incorporated into the information system. The inclusion of the ICD database search application (see section 5.3.6) is an example of incorporating an end-user requirement into the information system. The descriptive information collected by and incorporated into the information system (see section 5.2.2) is required by the Medical Research Council.

6.2.3 Finance

Financial obligations often influence projects. Costs associated with project implementation, as found by Broens, includes the initial investments, as well as the maintenance and operational costs. In the research phase of telemedicine projects, the costs are funded by various sources such as the government, private donors, and research grants. However, as soon as the pilot phase of the project is completed, a lack of financial input proves to be a barrier to the effective operation of the new system [51].

The majority of the costs associated with the information system occur during the development phase of the project and it is all software related. The financial requirement for the information system during its operation is only the hosting fees of the internet site.

Additional costs, associated with the information system, are for user training. This expense is the responsibility of the Medical Research Council. They will have to identify the people who must go on courses and also make the required financial arrangements. The knowledge obtained by attendees at the courses can be shared in-house, which reduces future expenses with regards to training.

The Medical Research Council includes an IT department that will provide technical support. They are also in a position to host the information system since they have a server capable of hosting.

6.2.4 Organisation

The study performed by Broens indicated that a lack of a working protocol for telemedicine projects exists. The projects implemented within an organisation are not always compatible with the existing structure of the organisation [51]. It is thus important that the existing infrastructure of the organisation, which in this case is the Medical Research Council, be taken into consideration during the design of the information system.

The information system developed in this thesis does not require any changes in the infrastructure of the Medical Research Council, as it does not impact any operational procedures. The information system aims to assist the Medical Research Council, in achieving its goals of documenting and managing information pertaining to telemedicine projects in South Africa. Hence, the acceptance of the information system by the Medical Research Council is not influenced by organisation resistance or a lack of infrastructure.

6.2.5 Policy and Legislation

Legislation and policy responsible for telemedicine and the application of telemedicine systems are still in its infancy. According to Broens, the current form of legislation is unsuitable for all aspects of novel telemedicine implementations. Standardisation and security also raises some issues when implementing a telemedicine system [51]. This has a direct impact on the information system developed in this thesis. Security and privacy issues are major areas of concern for any system responsible for the collection, storage and management of information. Even if the information handled by an information system is not confidential, it is required by law to provide the users of the information systems with adequate security and privacy measures.

The information system in this project includes a feature that hashes (scrambles and hides information behind random characters) the users' passwords. The only way to retrieve the password is to complete the security question provided during the user registration process. This is one of the most effective methods in securing a user's password. However, if the

password is lost, the administrator of the information system cannot assist in the retrieval of the password. Another method is to store the user's password in the database without any encryption. It is easy to retrieve the password if lost, but this method is not allowed as it is against the law, due to it being in violation of the user's trust. It also breaches the privacy requirements pertaining to the hosting of a website.

To comply with governmental policy and legislation concerning the hosting of a website, a link is included on every page of the information system, directing users to the terms of use and the privacy conditions governing the use of the information system. These links inform users of the external content which runs on the website, any third party applications that are utilised by the system and also the sharing and use of information collected by the information system.

6.3 Pitfalls to Avoid when Implementing Information Systems

While healthcare may present some unique problems in the attempt to implement automated information systems; systems engineers have perpetually been dealing with similar problems in the introduction of technology into other businesses. Sage [55] identified the following list of potential pitfalls in systems implementation:

An over-reliance on a specific analytical tool or technology might be encouraged, which is advocated by a certain group [35]. This could refer to the software and design methods used to develop the information system. Training and experience of the developer will influence the design of the system. It is for this reason that tried and tested design methods and software are utilised for the design of the information system. In addition, in the case of using the information system developed in this project, the use of the ICD search application can be seen as a technology that can create an over-reliance on the technology by some users. It can lead to the neglecting of verifying the result obtained by the application, with the corresponding ICD code. To combat this possible issue, steps and procedures are included in the ICD search application, to ensure the correct use of the application.

Another potential pitfall, identified by Sage is the failure to involve the client in the problem resolution or system design alternatives [35]. To ensure that this did not happen, the Medical Research Council was identified as the primary stakeholder and consulted throughout the development and test phases of the information system. Their resources and knowledge

pertaining to telemedicine in South Africa proved to be useful in the design and implementation of the information system.

Sage identified the failure in properly relating the designed system to the cognitive style and behavioural constraints that affect the user, as a potential pitfall. In other words, the poor design of the human interface could prove to be problematic [35]. This is taken into consideration for the layout of the interface, for example, in terms of the colour scheme and the type of font used for the information system. The user should feel familiar and comfortable when using the system. Attention to detail and resolution capabilities of different internet browsers are also taken into account in the design of the information system. This ensures an aesthetically pleasing environment and a robust system, capable of functioning on multiple platforms to ensure a problem free user experience.

Furthermore, Sage identified that insufficient attention might be paid to the needs of reality, availability, and maintainability. Sage suggests that this may arise from the lack of an understanding of the system life cycle [35]. Figure 1-2 on page 5 shows the adapted system life cycle used for the development and implementation of the information system in this project. The use of an adapted system life cycle provided an opportunity to study the system life cycle and provide a better understanding of it. This ensured that all aspects of the project, including development, implementation, operation and maintenance, were considered throughout the project, to avoid the pitfall of improper attention and understanding of the system life cycle.

The final relevant pitfall mentioned by Sage, is the failure to integrate the system under development with the existing systems in the environment. The necessary proactive support from the management in the client or stakeholder group may not exist. Changes in the organisation and environment, as a result of the implementation of the new system, may not be identified [35].

Server capability is incorporated into the information system, which will ensure that it integrates into the existing environment without any compatibility problems. Verifying and validating the information system before it is transferred to the Medical Research Council (discussed further in Chapter 7), ensures that compatibility issues and possible problems are identified beforehand and fixed. The consideration of proactive support from the client is also addressed, by incorporating and consulting the Medical Research Council at various stages throughout the project, to ensure a positive working relationship.

The implementation of the information system will not force any changes at the Medical Research Council, since there is no similar system in place. It is important that the possible pitfalls identified are addressed and kept in mind with the implementation of the information system. This will reduce the probability of a problem occurring.

6.4 Implementing the Information System

The information system is hosted on a University of Stellenbosch server. The two types of servers, a Linux based server and a Windows based server, are available for use. As discussed in section 5.4, none of the hosting configuration options provided by the University of Stellenbosch can host the standard ASP.NET framework, in conjunction with the SQL database structure. For this reason the database is converted to a Microsoft Access structure (see section 5.2) and the website is hosted on the Windows server.

The method for communication between the developer computer and the hosting server follow the standard File Transfer Protocol (FTP). FTP is a standard network protocol used to transfer files from one host to another over a Transmission Control Protocol (TCP)-based network, such as the internet. The FTP method allows the developer to connect to the remote server by means of a username and password. The username and password are encrypted, unless otherwise configured by the server administrators, ensuring that the content of the information system is protected.

There are many design programs and software applications that incorporate the FTP connection method, allowing the developer to send and retrieve files from the remote server. Two such programs are Microsoft Visual Web Developer and Adobe's Dreamweaver, which were used during the development of the information system. Both programs include the FTP method. This allows the developer to maintain and manage the files of the information system on the local developing computer and the remote hosting server.

For the purpose of the information system developed in this project, Adobe Dreamweaver's built-in FTP method is used to manage the files on both the developing computer and the hosting server. It provides the developer with the option to synchronise selected files, or the entire project all at once.

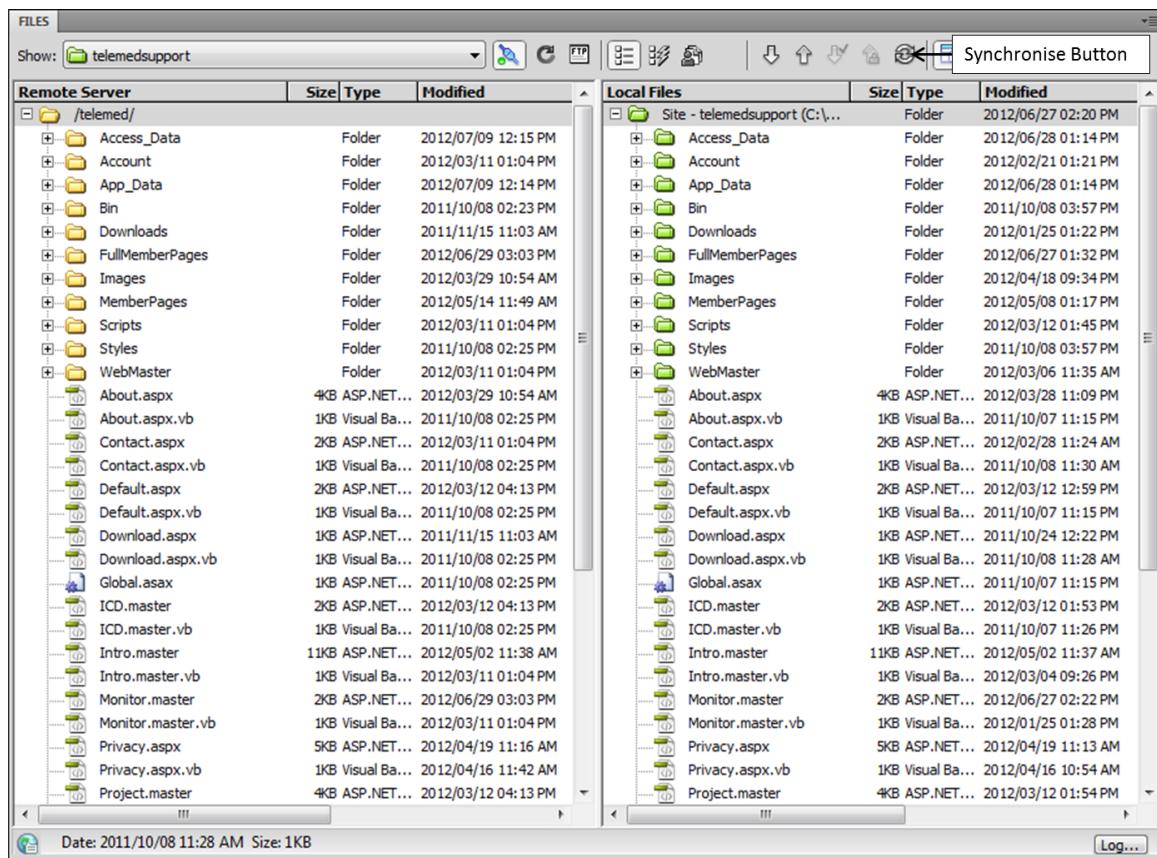


Figure 6-1: Adobe Dreamweaver File Management (Screenshot, Adobe Dreamweaver, 2012)

Figure 6-1 shows the FTP method using Adobe Dreamweaver CS5. Both sets of files, the local developer computer and the hosting server, are displayed next to each other. To transfer a file between the local machine and the hosting server, the file can be dragged and dropped to the desired location. The entire project can also be synchronised by clicking on the synchronise button located at the top right hand corner.

The URL associated with the information system is: www.telemedSupport.co.za. Once the verification and validation of the information system is complete (discussed further in the next chapter), the information system will be moved to the Medical Research Council's server. They will provide and be responsible for the hosting domain. The same method used to transfer the files to the Stellenbosch University server will be used.

6.5 Stress Testing

Due to the nature of the information that will be collected by the information system, stress testing is not required for the database. The amount of projects and users that will be registered

on the information systems will be comfortably within the limits of the database. The database file's size is limited to two gigabytes [56]. A table does not have a size- or count-limit; however, it cannot exceed the two gigabyte size limit imposed upon the database file. The size of the database file after the alpha-and beta-test (discussed in Chapter 7) did not exceed ten megabytes. This includes all of the user information as well as the telemedicine project information. There is thus ample room available for data to be added to the information system. Even if the database file's size reaches two gigabytes, Microsoft allows the Access database file to be split [56], increasing the storage capabilities of the database.

In terms of the maximum number of concurrent users that a Microsoft Access database can handle, 255 is the official number provided by Microsoft [56]. During the meta-study, the maximum number of users that operated simultaneously on the information system was five. During the beta-testing phase, which allowed the public to access to the information system, no more than twenty people concurrently used the information system. Thus, the limit of 255 concurrent users imposed upon the Access database file structure is sufficient.

6.6 Conclusion

In this chapter, the implementation of the information system was discussed. This included the determinants of a successful telemedicine implementation, as well as the determinant classification to ensure future success of the project. With each of the classification parameters, a brief introduction was given, followed by information about the influence they have on the system developed for the purpose of this study. Methods and contingencies to address possible concerns and issues with the system were also addressed at the various classifications.

Another aspect, taken into consideration during the implementation of the information system, was the possible pitfalls. Some of the more likely pitfalls were discussed and the method for avoiding and minimising the effect these pitfalls might have on the information system was also discussed.

The rest of the chapter was dedicated to the physical implementation of the information system. This included possible alternative methods for implementing the information system, as well as the reason why particular tools and applications are used to achieve certain tasks. The reason why there was no need for stress testing of the database was also discussed. The main reason for not performing a stress test on the Microsoft Access database was that all the storage

and usage requirements of the information system fall well within the maximum capabilities and limits of the Microsoft Access database.

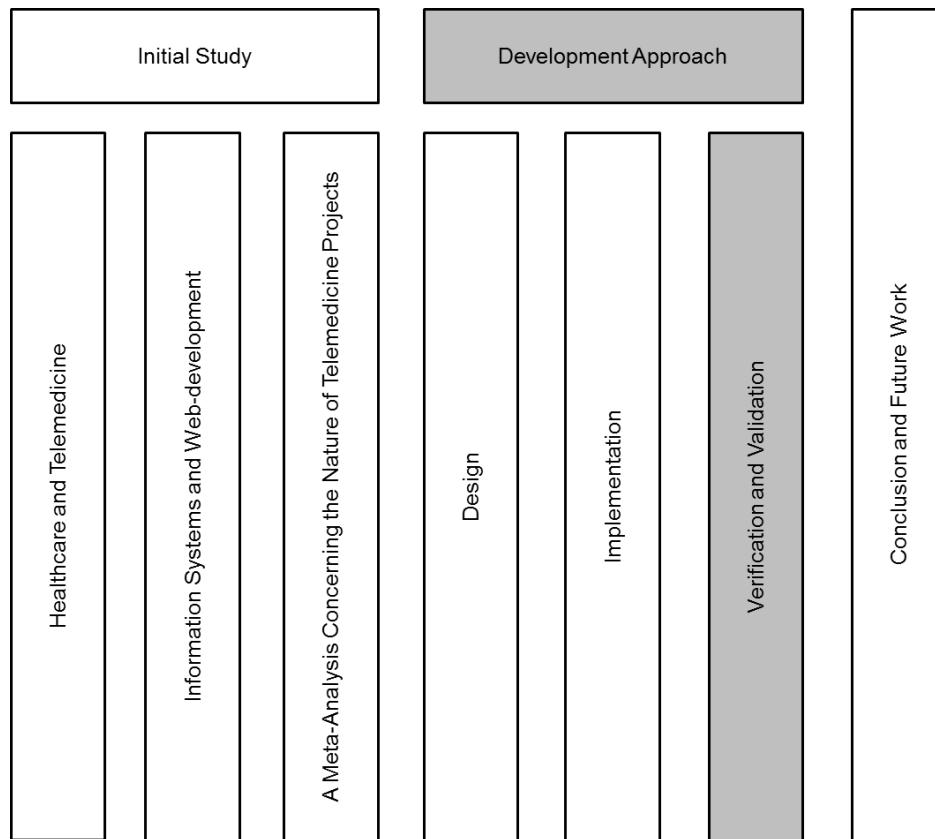
The next chapter concludes the development phase of the information system. This includes the verification and validation of the information system.

7. Verification and Validation

Verification is the act of reviewing, inspecting and/or testing the system during the development phase to ensure it meets the requirements set forth in the project outline [57]. Validation, on the other hand, is done at the end of the systems development or research process.

The word “validation” is derived from the Latin word “valere” which means “weight” and also relates to the word “value”. Within the context of the SDLC validation, it involves the testing of the system to ensure that it conforms to the needs of its users [57]. It is thus important to assess whether the system is of significant value to the user. Within the context of the research process, the value of the research output has to be determined by weighing up the extent to which the research problem is addressed. In addition, it is necessary to measure the extent to which the research output is able to fill the gap, defined at the offset of the research project, in the knowledge.

In this chapter, the means of verification of the information system, within the context of the SDLC, as well as the validity of the system, within the context of the research process, will be considered.



7.1 Verification

The verification process included two testing phases. The first testing phase, referred to as the alpha test, was performed during the meta-study (see Chapter 4). The second testing phase, referred to as the beta testing phase, was performed after the changes, necessitated by the alpha testing phase, were made. These were based on the requirements of the primary user, the Medical Research Council, and were incorporated into the information system. This verification phase can be considered a form of external user acceptance testing.

7.1.1 The Alpha Testing Phase

Alpha testing is often employed for off-the-shelf software/products as a form of internal acceptance testing, before the software goes on to the next testing phase [58].

7.1.1.1 Methodology

During the first week of December 2011, four industrial engineering students were selected to take part in the meta-study. This study served a dual purpose: the study aimed firstly, to analyse the nature of telemedicine projects in order to inform the structure of the database. The second purpose of the study was to serve as the first phase of the verification of the information system.

During the alpha testing phase, the user registration process, project information collection, the populating of the drop down list tables, and the role provider settings (allowing certain user access to certain areas of the information system) were tested. The participants in the study were requested to register on the information system and appropriate roles were then assigned to them. The users were given access to information collection forms, but not to the administration pages so that the user roles, associated with the information system, functioned properly.

User progress was monitored by tracking the time stamp associated with each project after it was uploaded. The project upload rate increased over time as a result of users becoming familiar with the information system. The research results, obtained during the study, were discussed in Chapter 4. The next section discusses the problem areas identified during the alpha testing phase.

7.1.1.2 Issues Identified during Alpha Test Phase

Most of the problems encountered in the development of the information system were related to the telemedicine process collection forms. No problems, concerning the functionality of the system or user permission, were identified during the study.

The first hurdle to arise was a delayed refresh time after additional information was added to a drop down list field. This was a source of concern for the users, who thought something had gone wrong and then proceeded to re-enter the information onto the system, causing a double entry to be made in the respective drop down list tables. However, when the delay between the uploading of the additional selection options and the selection options in the main collection form, became apparent, the users adapted accordingly and the efficiency of the project documentation process increased.

Another issue that arose during the study was that duplicate numbers were assigned to multiple projects. This error occurred because the project numbers were assigned to projects when users began their completion of the project forms. The refresh rate (or system latency), to check if another project has been added to the information system before the current form has been completed, was too slow. Hence, if two users finished documenting a project within 30 seconds of one another, the same number would be assigned to both projects.

No other problems occurred during the meta-study. The user registration process as well as the roles assigned to the users all worked. The articles, given to the users were also correctly registered on the information system. Also, the Microsoft Access database proved to be capable of accommodating simultaneous entries without problems.

7.1.1.3 User Feedback

The users were also asked to give feedback on their experience with the information system. According to them, the only hitch pertaining to the information system was the navigation between the forms that added the additional information to the drop down list fields. They suggested a pop-up style entry box next to each field on the main form as they felt this would reduce the time taken to refresh the content on the main form since all the activity happens on the same page.

Another concern was that the form, used to document a telemedicine project, is too long. The form, which consists of 52 entry fields, could become a deterrent if users are expected to document a number of telemedicine projects. Although it is important to collect as much relevant information as possible, the possibility of users abandoning the registration of a project, due to the length of the form, was a valid concern.

7.1.1.4 Changes to the Information System

After the concerns were identified and the feedback from the students taken into account, certain changes to the information system were made. The project numbers that were not updating correctly were removed since the numbers were only for display purposes. This functionality was re-allocated to the database where the numbers can be added to the database automatically once the user adds the project to the system. This removed the need to check if a project had been added by another user before being uploaded to the database. The project number is still, however, displayed on the website once a user visits the profile page that summarises the projects. The only change is that the project number no longer appears on the project registration form because a project number is only assigned to a project once it is uploaded to the database.

Double entries that occurred during the alpha testing phase because of the lengthy update time of the drop down list fields were manually removed using Microsoft Excel. The reason for the delay can be attributed to the AJAX update panel that is used to update only the section of the web page responsible for the drop down list's content. Although only a portion of the web page is refreshed, the web browser still performs the entire process of loading a new web page. The user does not see this process happening. This causes the update of the content of the drop down list field to be delayed.

To remove the double entries, the Microsoft Access database containing the projects uploaded during the alpha testing phase was exported to Microsoft Excel. Microsoft Excel's duplicate removing function was used to eliminate the duplicate entries. The new tables, without the duplicate entries, were uploaded to the original Microsoft Access database, overwriting the old content. In future, users will only have the option to select information from these tables. Thus, the option for users to add content to the drop down list fields are removed and the data

obtained from the alpha test will be used as content for the drop down list fields in the final version of the information system.

In future, if a user wants to add content to the drop down list field, a request will be sent to the system administrator and the administrator will add the information to the system if deemed necessary. Also, some of the drop down list fields, such as type of disease and specialisation, are populated using industry standard values. A comprehensive list covering the entire field has been added to the drop down list field content. This will provide future users with a comprehensive set of options, eliminating the need to add options to the drop down list field.

The number of fields, required to document the telemedicine process for each project, was also reduced as shown in Figure 5-4 on page 67. The method used to reduce the parameters in the documentation of the telemedicine process will be discussed in the next chapter, during the data analysis of the data obtained during the alpha testing phase. This revised version reduces the amount of entry fields which need to be completed, without sacrificing the comprehensive documentation of the telemedicine process.

An additional form was also included in the information system to collect other information pertaining to the project such as contact details, goals, objectives and funding details. This information is required by the Medical Research Council to document telemedicine projects in South Africa. The database for this form is shown in Figure 5-3 on page 66.

7.1.2 The Beta Testing Phase

Versions of the software, known as beta versions, were opened to a limited audience outside of the development team. The software was released to groups of people so that further testing could ensure the system has as few faults or bugs as possible. In some instances, beta versions are made available to the open public to increase the feedback field to a maximal number of future users. This testing methodology served as the final verification measure of the information system.

Unlike the alpha testing phase, which focused on data acquisition and storage features, this testing phase focuses on administrative and compatibility features. The administration and information management tools incorporated into the information system were tested to ensure they functioned properly. The ability of the information system to simultaneously register multiple users, who are not familiar with the system, was also tested. In addition, the system's

capacity to manage and maintain user registration information was tested. This testing phase required the information system to be accessible by users outside the Stellenbosch University network.

7.1.2.1 Methodology

The users who participated in this testing phase were all people involved with telemedicine in South Africa and were identified by the Medical Research Council from their database. A mass e-mail was sent to those selected to participate requesting them to register by following the link in the e-mail to the information system. Appendix F contains the e-mail that was sent to the potential users.

After the message had been sent, users frequented the website and those that opted to register on the system provided the required information to complete the user registration process. In addition to registering, the users were asked whether they knew of an existing telemedicine project which could be documented on the information system. During this testing phase, 105 users registered on the information system and 70 users indicated that they knew of a telemedicine project.

If users indicated that they knew of a project, they gained full access to the website (full member role) and were allowed access to the telemedicine project registration form. If a user added a telemedicine project (the project documentation form used for this test is shown in Appendix D) to the information system, the project was displayed on their profile page. Here, users can navigate to any of the projects they have added and edit any information on the selected telemedicine project. They can then also add the telemedicine process information for the given project. This method allows users to register telemedicine projects, with the information they have at their disposal, and add any additional information as it becomes available.

This reduces the likelihood of a user opting not to register a project because the documentation form is too long or inadequate information is available. It also allows project information to be kept up to date since users can edit the information at any time.

7.1.2.2 User Registration Data

The period for registration was from the 2nd of April 2012 to the 29th of July 2012. Figure 7-1 illustrates the weekly number of users that registered on the information system.

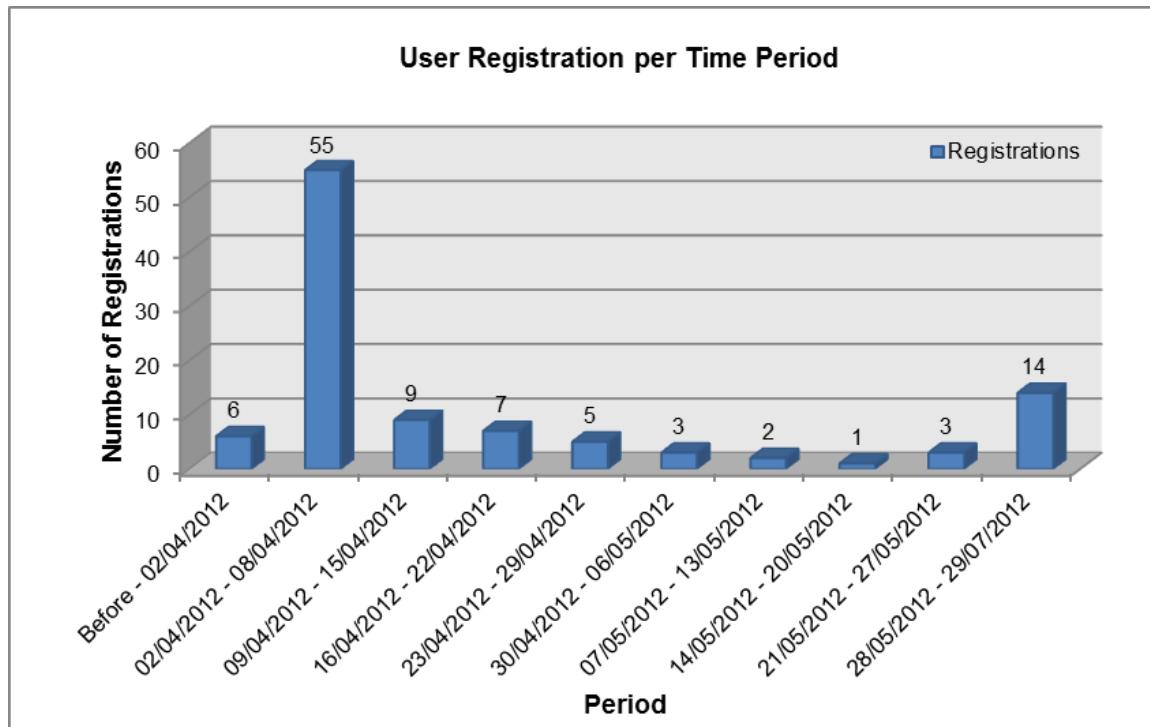


Figure 7-1: User registration over the period 02/04/2012 - 29/07/2012

The six users that registered on the information system before the registration period opened, included the administrator of the information system, the four industrial engineering students who assisted during the alpha testing of the information system, and one user that requested access to the ICD database search application (see section 5.3.6). These users also participated in the beta testing phase, hence the inclusion of their registration information.

The first week had the most registrations. This can be attributed to the mass e-mail sent to the MRC's mailing list. The e-mail triggered an immediate response from users as can be seen in Figure 7-1. However, after the first week of registration, a gradual decline in the number of registrations was observed. This was to be expected since the effect of the e-mail, requesting users to register, inevitably fades over time. The reason for the small spike on the last bar of the graph is because another e-mail, requesting users to register on the information system, was sent.

The registered users were classified into one of three categories (user roles); full member, member, and administrator. Users were automatically placed into one of the member categories according to their registration options. Users, who indicated prior knowledge of a telemedicine project that could be documented on the information system, were assigned to the role of full membership and users who did not, were assigned to the membership role. An administrator can only be appointed by another administrator so this process had to be performed manually.

Full members had access to all the web pages, except the administration pages, allowing them to add a telemedicine project to the database. Members did not have access to telemedicine project information and registration options, but they did have access to the utilities function of the information system which included the ICD database search application. Figure 7-2 illustrates the user categories, according to their roles.

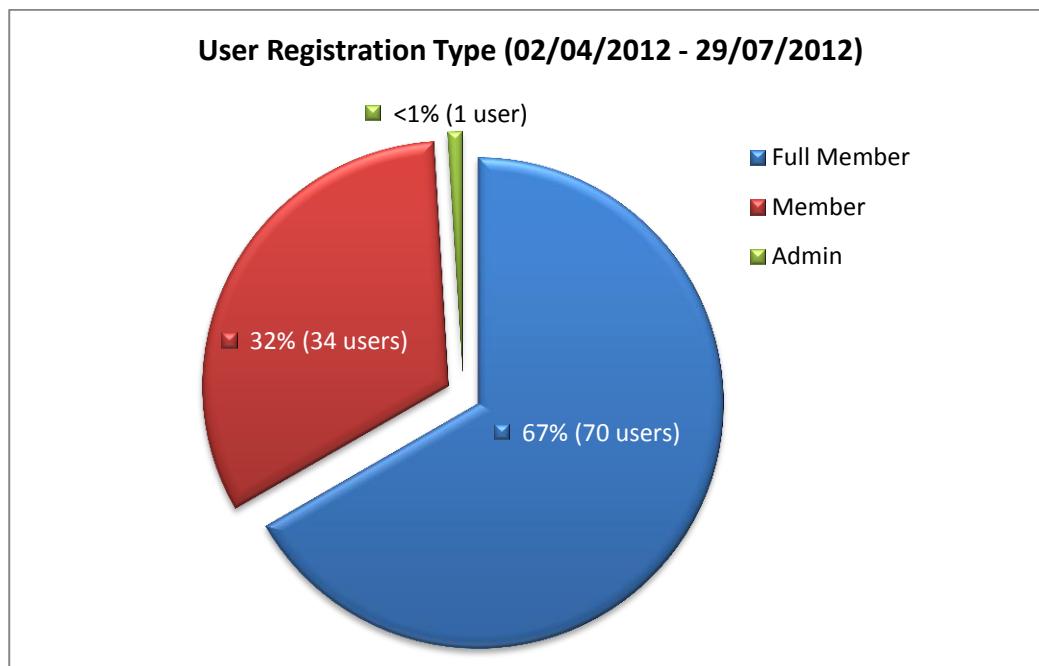


Figure 7-2: Number of users in a specific role

7.1.2.3 Telemedicine Project Data

Users were allowed to add an unlimited number of projects to the information system. This was to facilitate the creation of a comprehensive database, identifying all the telemedicine projects in South Africa. Ideally, the person responsible for the telemedicine project also had to upload and maintain the telemedicine project information.

The first step was for a user to register a project on the information system, using the project documentation form shown in Appendix D. After this, the project was added to the user's profile page where a user would be able to edit the information. If users select the edit page, they would be requested to complete the telemedicine process form for the project.

From the 2nd of April 2012 until the 29th of July 2012, twenty one telemedicine projects were registered on the information system. Unfortunately, these projects only included descriptive information as requested by the project documentation form and not telemedicine process information. This could be because telemedicine projects in South Africa are not documented properly resulting in the information not being available to the people registering the project on the information system.

Figure 7-3 shows the number of telemedicine projects according to the province in which they were initiated. According to the information system, all the projects listed are currently active in South Africa. These projects are also displayed on a Google map, shown in Figure 5-7 on page 73.

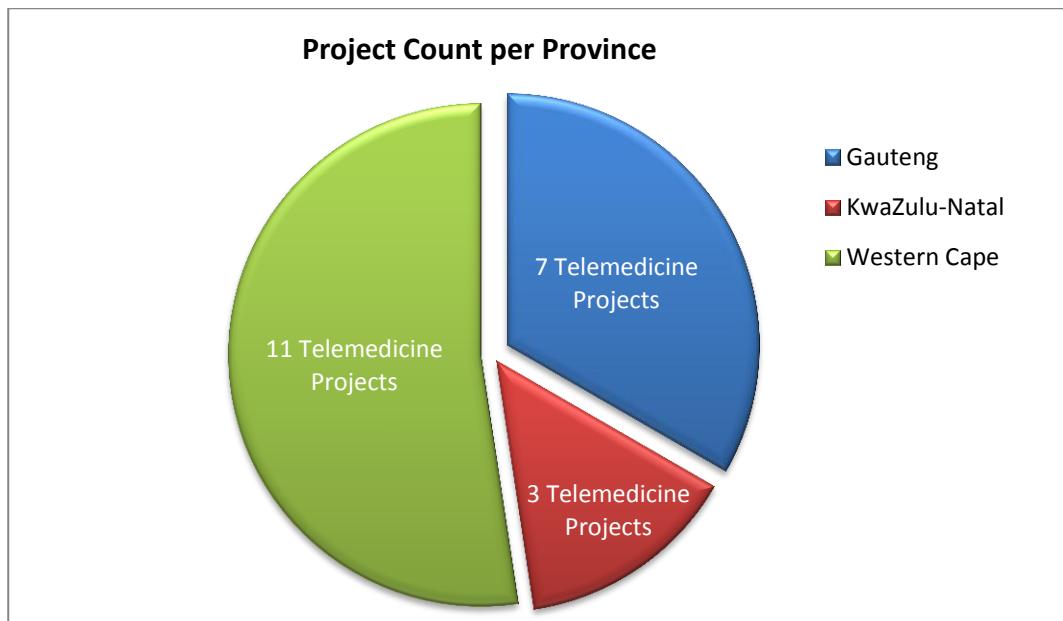


Figure 7-3: Registered provincial telemedicine projects

7.1.2.4 Issues Identified during Beta Test Phase

The user registration process was made up of two steps. In the first step, the user provided a username, password, e-mail address, and the answer to a security question. This is the default

registration process included by the ASP.NET framework. Once users have completed the user registration form, they are assigned a unique system identification code (primary key). The second step required users to provide their personal information including first name, last name, occupation, and designation. This information was then stored in a separate table in the database and was connected to the user's profile by the unique system identification code.

However, a problem arose at the second step of the user registration process during the beta-test. Some of the users' information was omitted from the information system after the second step of the registration process because of browser incompatibility. Users who had used Apple's Safari Internet browser did not see the submit button in the second form of the registration process. This was due to code compatibility issues between the web page and the browser. The reason this problem did not occur in the first step of the registration process was because a different, and more compatible, submit button was used.

Another mishap occurred during the registration of a telemedicine project. Certain users noted that the projects they had registered, using the telemedicine process registration form, did not appear on their profile pages. On further inspection, it appeared that the project did not register on the information system. This error occurred because some of the data entry fields on the project registration form were of the wrong type. The data field type for describing the goals and objectives of the project were set as a text-field which, in Microsoft Access, is limited to 255 characters. Thus, if someone had completed the field with a text-field data type, Microsoft Access would ignore the entire uploading process and not only the specified field. The solution was to change the data field type to a memo-field in the Microsoft Access database since this field allows an unlimited number of characters to be stored in the database.

During registration, a few of the users forgot their login details which posed a problem in that, the password recovery feature had not been included during the initial stages of the beta-test due to limited server capabilities. Thus, in the case of forgotten login details, the administrator would have to reset the details manually. This became increasingly problematic as more users registered on the information system and forgot their passwords.

7.1.2.5 Changes to the Information System

As a consequence of the Safari Internet browser problem being identified, the input button on the second user registration form was changed to the same button-type as on the first user

registration form. This provided an effective solution and enabled users of the Safari browser to complete both steps of the user registration process.

A further alteration, made to the information system, was to change the data field types of the process registration to the memo-field data types. This allowed more characters to be stored for a given field in the database and prevented project registration errors.

The final change made to the information system during the beta testing phase was the inclusion of the password recovery feature. The appropriate SMTP (Simple Mail Transfer Protocol) settings of the hosting server need to be provided before a user can utilise the ASP.NET password recovery system. This allows the information system to utilise the outgoing e-mail function of the hosting server. In the case of Stellenbosch University, the general SMTP settings are incorporated into the information system which allowed users to retrieve their passwords by providing answers to the security questions. After completing this step, a new password is sent to their e-mail addresses which they can then use to log in to the information system, after which, they can change their password.

7.2 Validation

Validation involves the testing of the product, service or system at the end of development to ensure that it conforms to the needs of its users [57]. Within the context of the research process, the value of the research output has to be determined by weighing up the extent to which the research problem has been addressed. This begs the question of whether the research output has successfully filled the gap in the knowledge, defined at the outset of the research project. The information system developed in this thesis was validated by ensuring that the research objectives stipulated in Chapter 1 are achieved. The next section revisits the objectives and examines the extent to which the information system has addressed them.

7.2.1 Aligning the Objectives of the Study with the Information System

The first objective of the information system was to assist in identifying methods for best practice in telemedicine implementation by identifying past projects of a similar nature. The information system developed in this thesis allows users to search for telemedicine projects, documented during the meta-analysis study, by using pre-determined filters. A user can also

search for a similar project and then view the telemedicine process information documented by the project.

The second objective of the project was to provide the Medical Research Council with an information management (collect-and retrieve) tool for telemedicine research in South Africa. The information system allows the registration of users and telemedicine projects. The projects can be filtered, monitored, and displayed on a Google map. This would assist the Medical Research Council in identifying the main role-players in, as well as providing an overview of, telemedicine projects in South Africa. The validation of this objective is discussed in more detail in the next section.

The third objective was to assist the Medical Research Council in achieving a key deliverable which was to collate a comprehensive database for m-Health initiatives in South Africa. The descriptive information, collected by the information system designed as part of this study, conforms to their requirements of documenting m-Health initiatives in South Africa.

The final objective of the project was to provide an “open source” web-based resource for telemedicine in South Africa. The information system, developed in this thesis, is indeed a neutral platform, incorporating unbiased data from individuals across the country. No preference has been given to any financial/academic institution and the content portrayed on the website is not financially motivated. The information can be accessed by anyone who registers on the information system.

7.2.2 Validation at the Medical Research Council

A meeting was arranged with Dr. Sam Surka for assessment of the information system, and to determine if it conforms to the needs of the Medical Research Council. Dr. Sam Surka is responsible for project design and management relating to telemedicine and m-Health at the Medical Research Council. Dr. Surka was thus in an excellent position to certify that the information and data collected, align with the National Department of Health’s (NDoH) monitoring and evaluation requirements, and conform to the Medical Research Council’s research requirements.

7.2.2.1 Methodology

The Medical Research Council requires an accessible online registry that contains relevant information on telemedicine projects in South Africa. The online system must be able to actively collect information about telemedicine projects in South Africa and the registry must be kept up-to-date. In addition, an important function of the registry is to assist in the planning, development, implementation, and researching of telemedicine projects.

The validation process at the Medical Research Council is divided into two categories. The first category is to ensure that the information system meets the telemedicine research requirements of the Medical Research Council. The second includes a validation of the system's capability to assist in the planning, development, implementation, and research of telemedicine projects. It was in this category that Dr. Surka's experience and involvement with telemedicine projects was the most useful.

7.2.2.2 Research Requirements of the Medical Research Council

The telemedicine research requirements of the Medical Research Council are:

- Accessible online registry;
- Actively collect information;
- Registry being kept up-to-date.

Users can register on the information system and view information pertaining to telemedicine projects (see section 5.3.2). This includes the article database (populated during the meta-study) and the project database (on-going process). This satisfies the requirement for an accessible online registry.

Concerning the second requirement, the information system allows telemedicine projects to be documented and stored. This is done using the database and collection forms (see section 5.3.3) of the system.

The information system also provides up-to-date information by connecting the telemedicine projects uploaded to the system with a user's profile. This allows the user to continuously update information, regarding a specific telemedicine project, thereby ensuring that the registry is kept up-to-date.

7.2.2.3 Assisting Telemedicine Projects in South Africa

The information system's capacity to assist in planning, development, implementation, and research can be determined by retrospectively examining two telemedicine projects in which Dr. Surka was involved. According to Dr. Surka, at the time, there were no reference or support frameworks available for telemedicine projects.

The first project was a teleophthalmology (branch of telemedicine that deals with the anatomy, physiology and diseases of the eye) pilot project conducted in the Eastern Cape [59]. The objective of the study was to evaluate the efficacy of screening diabetic patients for diabetic retinopathy in a resource-limited rural setting using a teleophthalmology service.

A non-mydriatic fundus camera was used to capture images of both retinas. The images were then saved onto a flash disk and transported on a weekly basis to the Department of Ophthalmology at the Nelson Mandela Academic Hospital in Mthatha for assessment by a specialist. Feedback on the images was given and any patient that required treatment was then referred on.

However, only 36% of all the diabetic patients at the clinic were screened during the pilot project (January to November 2007). This relatively small percentage can be attributed to a number of factors, including the lack of a support framework where similar projects could be identified and accessed to assist in the planning, development, and implementation of such a teleophthalmology system.

Using the information system to filter out projects documented during the meta-study, eight ophthalmology projects were returned. Figure 7-4 shows how the information system was used to perform this task.

BROWSE THROUGH ARTICLE DATABASE			
The database below is a summary of articles collected from various journals during a meta-analysis. Use the drop down lists to filter the projects. Click on the name of the article to get a full report.			
Implementation Layer	Specialization of Project	Disease of Project	Purpose of Project
--Select--	Ophthalmology	--Select--	--Select--
Projects Matching Search Parameters: 8			Reset Page to Default State
Num	Name of Article	Authors	Outcome
8	Mobile digital fundus screening of type 2 diabetes patients in the Finnish county of South-Ostrobothnia	Riku Lemmetty and Kari Makela	Prevent blindness. Also, improve efficiency of ophthalmology services.
11	A pilot trial of tele-ophthalmology services in north Wales	Manoj Kulshrestha, Delyth Lewis and Chris Williams	Reduce unnecessary ambulans trips to hospital from clinic by correctly identifying referral cases using telemedicine.
32	A pilot teleconsultation network for retinal	Claudio Azzolini	Over 4 weeks or trial 89% of doctors used the teleconsultation network

Figure 7-4: Filtering information by Specialisation “Ophthalmology” (Screenshot, 2012)

One of the articles, entitled “*A pilot tele-consultation network for retinal diseases in ophthalmology*,” directly related to the project performed by Dr. Surka. Figure 7-5 shows the information output after the filter query was performed. Dr. Surka confirmed that the telemedicine process information about this project would have been helpful had it been available when his project was piloted. He stated that it would have provided a useful frame of reference for the project.

TELEMEDICINE PROCESS DETAILS ABOUT ARTICLE: A PILOT TELECONSULTATION NETWORK FOR RETINAL		Back to Articles
Authors		Claudio Azzolini
Outcome	Over 4 weeks or trial 89% of doctors used the teleconsultation network	
Journal Name	Journal of Telemedicine and Telecare	
Volume	17	
Country Name	Italy	
Implementation Layer	Pilot	
Purpose of Project	Remote Consultation	
Disease	Eye Disease	
Specialization of Project	Ophthalmology	
Who collects		Doctor
What is collected		Medical Information and Images
Where is it collected		Hospital
When is it collected		Appointment
How is it collected		Digital Camera

Figure 7-5: Information returned (shortened) for the article: “*A pilot tele-consultation network for retinal diseases in ophthalmology*” (Screenshot, 2012)

The additional ophthalmology related articles returned by the filter also contained useful information and feedback. Furthermore, the filtered articles served as a literature repository to

support the project. If Dr. Surka had wanted to read the entire article, a Google search of the name would have directed him to the article.

Other filters, applied to the database, also yielded positive results. Setting the “*purpose of project*” filter to “*specialist support*,” returned 14 articles related to providing specialist support. Filtering the information according to the implementation layer, in this case “*pilot project*,” returned 16 articles related to pilot projects.

Moreover, when managing the change process, much could have been learned from previous projects. For example, in the developed world, nurses and healthcare workers play a more prominent role. The teleophthalmology project, piloted by Dr. Surka, required a doctor to collect the necessary information. Since doctors in South Africa are in such short supply [60], using the information system to find projects where nurses collected information (12 results were found) would have been helpful. Although these projects were of different disciplines, the results and information could still have been utilised to provide guidance and assistance to create a similar process whereby nurses collect the information, rather than taking up the valuable time of doctors to do this task.

The second project was the setup of a teleophthalmology service at the Grabouw Community Health Clinic in the Western Cape. The objective of the project was to improve the referrals made by clinicians at a rural healthcare facility in South Africa [61].

A teleophthalmology station was implemented at Grabouw Community Health Clinic. Patients who had an abnormal fundus examination (performed using mydriatic eye drops) were referred to the teleophthalmology station rather than being directly referred to the eye clinic. Here, a digital fundus photography assessment, with real-time transmission to a remote eye specialist, was performed. The specialist was available to provide immediate feedback on the images and if a patient still required attention, they were then referred to the eye clinic.

Once again, using “*ophthalmology*” as filter in the information system, similar projects were identified. One project indicated a method that allowed adequately trained general practitioners to screen for treatable lesions of diabetic retinopathy, with a high level of reliability, using non-mydraticretinography. Another ophthalmology-related project indicated a method of preventing blindness and improving the efficiency of ophthalmology services. Dr. Surka again confirmed that the information returned by the system would have been useful had it been available at the time.

Using the purpose of the project as a filter, and selecting “*Improve referral process*”, one article was returned. Changing the selected option to “*minimise inappropriate referrals*” returned two articles. Although these projects addressed different specialisations, the feedback and discussion concerning possible barriers and issues were found to be applicable to the project performed by Dr. Surka.

It is therefore evident from the two projects discussed, that the information system can play a role in assisting the planning, development, implementation, and research of telemedicine projects. It also assists in identifying literature that can be beneficial during the initial study of a telemedicine project.

7.3 Conclusion

This chapter discussed the verification and validation of the information system. The verification of the information system included two testing phases. The first testing phase was conducted during the meta-study. This included the testing of the information collection forms, user registration process, and the user role provider feature. After the test, user feedback and problems that arose during the test were taken into consideration and the appropriate changes were made to the information system.

The second testing phase allowed users from outside Stellenbosch University’s network to access the information system. This tested the system’s ability to accommodate multiple users, accessing and registering information simultaneously. It also provided an opportunity to test the information system with regards to system compatibility. Multiple users with different settings accessed the website and the most significant compatibility problem existed when the Safari Internet browser was used during user registration. After the administration pages were tested, they proved to be capable of managing and maintaining the information stored in the information system.

The validation of the information system indicated that the objectives stipulated in Chapter 1 were indeed achieved. An additional validation procedure was done at the Medical Research Council to ensure that the information system met their requirements. This validation procedure indicated that the information system meets the Medical Research Council’s demands for assisting in the planning, development, implementation, and research of telemedicine projects.

8. Conclusion

In this chapter the research and development process adopted in the execution of this thesis are reflected upon, and the possibility for future projects is suggested.

8.1 Reflection

The literature review, also referred to as the initial study of the System Development Life Cycle used in this research project, included a background of healthcare and telemedicine (Chapter 2). It also included a study concerning information systems and web-development (Chapter 3).

The development approach of the information system was twofold. The first part consisted of the development of a database (section 5.2.1) and interface (section 5.3.3), to collect information pertaining to the telemedicine process. This database and interface were used during the meta-study (Chapter 4). The second part consisted of developing a database (section 5.2.3 and section 5.2.4) and interface (section 5.3.3), to document telemedicine projects within the South African context. This included descriptive information and telemedicine process information.

The meta-study described in Chapter 4 served as a means to populate the information system with descriptive- and telemedicine process data from past projects. For the study, four final year engineering students were asked to test the information system and document the articles obtained from the *Journal of Telemedicine and Telecare*.

In Chapter 6, literature pertaining to the determinant classification for successful implementation of projects was discussed. The impact of these classifications and the measures taken to incorporate these classifications into the information were also considered (section 6.2). In addition, literature relating to the pitfalls when implementing a system was included in this chapter (section 6.3). The method for implementing the information system was discussed in section 6.4.

The verification and validation of the information system was discussed in Chapter 7. The verification was performed in two phases. The first phase, the alpha test, was performed during the meta-study (section 7.1.1). The second phase, the beta test, was performed towards the end of the project (section 7.1.2). The validation of the information system was discussed in section 7.2. This included a discussion on how the information system addressed the objectives (section

7.2.1) stipulated in Chapter 1 and whether it met the requirements of the Medical Research Council (section 7.2.2).

8.2 Research Process

Lategan et al. [62] explains that research relates to the creation of new knowledge and can be defined as a process of critical analysis to solve a problem. Three important components of research are identified by Lategan as:

1. Critical knowledge enquiry;
2. Discovery of new knowledge;
3. Implementation and application of new knowledge.

The next few sections discuss how these components were addressed by the research project discussed in this thesis.

8.2.1 Critical Knowledge Enquiry

Basic research investigates a problem against the background of a specific subject. The knowledge obtained from this study can then be utilised to solve the problem. This is done through scientific investigation based on critical inquiry, discovery, systematisation of facts and evidence, and the formulation of new theories [62].

The critical knowledge enquiry aspect of the research process was conducted and discussed in Chapter 4, the meta-study. In this chapter, a process to describe and document telemedicine systems was identified, tested, and refined.

8.2.2 Discovery of New Knowledge

Research works on the basis of identification (similarities) and distinction (differences) [62]. The output of the meta-study performed in Chapter 4 answers the second world problem, identified by Mouton et al [63]; “The aim of science is to generate truthful (valid and reliable) descriptions, model and theories of the world.” The output of the study identified a framework that can be utilised to define and document telemedicine systems.

8.2.3 Implementation and Application of New Knowledge

The new knowledge obtained during the course of the meta-study served as the foundation on which the information system developed in this thesis was built. The revised/shortened version of the telemedicine process, discussed in Chapter 4, was then incorporated into the information system and will be used to document telemedicine systems in South Africa. This pertains to future work, discussed in the next section.

The information system developed for the purposes of this thesis is not merely an operational tool, but is designed to facilitate the gathering of telemedicine information towards the application of new knowledge regarding telemedicine projects in South Africa.

8.3 Suggestions for Future Work

The column headings in Table 8-1 show two parallel research and development processes that were followed in an integrated method. The row headings, namely; development, testing, verification, and validation relate to the Systems Development Life Cycle. In the table, references are made, in the respective cells, to the section of the thesis relevant to that part of the process.

The meta-study described in Chapter 4 served as a means to populate the information system with descriptive- and telemedicine process data from past projects (refer to the second column of Table 8-1). In Chapter 7, an explanation was given on how the meta-study supported the verification of the information system. Furthermore, the extent to which the telemedicine process data addresses the validity of this research project was discussed in section 7.2.2.3.

The third column of Table 8-1 applies to information obtained for telemedicine projects within a South African context. Unfortunately due to the longitudinal nature of the study, the validity could only be anticipated by extrapolation from the meta-study.

Table 8-1: Component breakdown of the two types of information used in this thesis

Components	Telemedicine Project Information from Literature	Telemedicine Project Information from South African Context
Telemedicine Process Data	Telemedicine project information derived from international academic domain. <i>Journal of Telemedicine and Telecare</i> Meta-Analysis (102 Projects) Chapter 4	Future Work Section 8.2.1
Telemedicine Descriptive Data	Telemedicine project information derived from international academic domain. <i>Journal of Telemedicine and Telecare</i> Meta-Analysis (102 Projects) Chapter 4	Actual projects in the South African context. Web Sources, User Knowledge Beta Test (21 Projects) Chapter 7
Verification • User Registration • Role Providers • Administration Features • Information Management • Compatibility	Alpha Test Section 7.1.1	Beta Test Section 7.1.2
• Data Collection • Visualisation	Meta-Analysis Sections 4.4 – 4.5	Beta Test Section 7.1.2.3
Validation • Project Objectives • Management Tool • Telemedicine Platform • Collate Database • MRC's Research Requirements		Discussion concerning objectives of study and meeting with Dr Surka at the MRC Sections 7.2.1, 7.2.2.1, 7.2.2.2
• Find Similar Projects • Assist telemedicine planning, development, implementation, and research	Meeting at MRC with Dr Surka Section 7.2.2.3	Future Work Section 8.2.2

The following is recommended with regards to future work:

8.3.1 Telemedicine Process Data within a South African Context

The projects registered on the information system with regards to the South African context do not contain all the information requested. Some of the projects have been active for an extended period and the required telemedicine process information is not available. However, by documenting future projects from the start, this issue can be rectified.

Additional work could include implementing a process to formally request that all future telemedicine projects in South Africa are registered and documented, on the information system developed in this thesis. This will ensure the establishment of a complete and comprehensive database, containing information pertaining to telemedicine projects in South Africa.

8.3.2 Assisting Telemedicine Research within a South African Context

Once the database contains a sufficient amount of data pertaining to the telemedicine process, a validation procedure, similar to that performed in section 7.2.2, can be performed. This will indicate if similar projects, within the context of South Africa, can be identified and if the information stored in the database will be capable of assisting the planning, development, implementation, and research of telemedicine projects in South Africa.

Future work can include projects assisting the National Department of Health's (NDoH) vision for e-Health in the short, medium and long term. In order to comply with the e-Health strategy, outlined by the NDoH, work in ten priority areas needs to be coordinated [64]. The following areas, as noticed in this, were identified:

- Strategic Priority 2: Stakeholder Engagement;
- Strategic Priority 9: Applications and Tools to support Healthcare Delivery;
- Strategic Priority 10: Monitoring and Evaluation of the e-Health Strategy.

In order to succeed, collaboration between all stakeholder groups affected by e-Health, including m-Health and telemedicine, must be initiated [64]. Building on the user registration feature of the information system developed in this thesis, to include multi-disciplinary collaboration features, is a possibility that can support this priority area.

There exists a wide range of applications and tools with the potential to support and improve healthcare delivery. The applications include electronic medical record systems, healthcare information systems, electronic content management, decision support, and knowledge management [64]. The opportunity to expand the information system developed in this thesis and include tools and applications, such as the ICD search application (section 5.3.6), to support this priority area, exists.

It is essential to monitor and evaluate the performance of the e-Health strategy on an on-going basis. This will ensure that the objectives are being met and that input for future planning is being made [64]. A research project, expanding the structure of the information system, developed in this thesis, to include the performance measures to monitor and evaluate the e-Health strategy, can contribute towards the NDoH's vision:

"e-Health: enabling a long and healthy life for all South Africans."

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Appendix A – User Analysis

User Analysis (Excel extract) – This analysis indicates the similarity between the users for each of the entry fields required during the meta-study. Three articles were used to determine the similarity between the users completing the documentation form. The aggregate similarity between the users for each article is also calculated.

25% - Each student selected a different option		50% - Two students selected the same option			75% - Three Students selected the same option			100% - All four students selected the same option				
User	Name of Project	Country	Implement	Purpose	Disease	Specialize	Diagnose	UseWho	UseWhat	UseWhen	UseHow	UseWhere
User 1	A pilot trial of tele-ophthalmology services	229	1	4	12	12	...	14	51	41	7	29
User 2	A pilot trial of tele-ophthalmology services	229	5	20	8	12	...	88	51	41	14	87
User 3	A pilot trial of tele-ophthalmology services	229	1	9	12	12	...	21	150	76	7	87
User 4	A pilot trial of tele-ophthalmology services	229	1	9	12	12	...	14	51	41	7	29
Most Common =		229	1	9	12	12	...	14	51	41	7	29
Similarity # =		4	3	2	3	4	...	2	3	3	2	3
Similarity % =		100%	75%	50%	75%	100%	...	50%	75%	75%	50%	75%
<hr/>												
User	Name of Project	Country	Implement	Purpose	Disease	Specialize	Diagnose	UseWho	UseWhat	UseWhen	UseHow	UseWhere
User 1	A web-based remote radiation treatment	110	15	3	1	14	...	14	49	41	7	29
User 2	A web-based remote radiation treatment	110	15	3	1	14	...	88	49	41	14	87
User 3	A web-based remote radiation treatment	110	15	3	1	14	...	21	49	55	7	87
User 4	A web-based remote radiation treatment	110	15	3	1	14	...	14	49	41	7	29
Most Common =		110	15	3	1	14	...	14	49	41	7	29
Similarity # =		4	4	4	4	4	...	2	4	3	3	2
Similarity % =		100%	100%	100%	100%	100%	...	50%	100%	75%	75%	50%
<hr/>												
User	Name of Project	Country	Implement	Purpose	Disease	Specialize	Diagnose	UseWho	UseWhat	UseWhen	UseHow	UseWhere
User 1	Home-based speech treatment for Parkinson's	14	7	1	27	10	...	14	3	25	7	29
User 2	Home-based speech treatment for Parkinson's	14	9	1	3	19	...	41	3	137	25	29
User 3	Home-based speech treatment for Parkinson's	14	9	1	3	17	...	14	3	25	7	29
User 4	Home-based speech treatment for Parkinson's	14	3	1	3	10	...	14	3	25	7	21
Most Common =		14	9	1	3	10	...	14	3	25	7	29
Similarity # =		4	2	4	3	2	...	3	4	3	3	4
Similarity % =		100%	50%	100%	75%	50%	...	75%	100%	75%	75%	100%
<hr/>												

Figure A-1: User consistency analysis (extract from Microsoft Excel)

Appendix B – Data Dictionary

<u>Field</u>	<u>Field Components</u>			<u>Type</u>
Project_Location	=	Latitude	+	Text
		Longitude		Text
Technical_Information	=	ImplementationLayer	+	FK
		Purpose	+	FK
		Disease	+	FK
		ICD_Range	+	FK
		Specialization	+	FK
		Collect_Who	+	FK
		Collect_What	+	FK
		Collect_When	+	FK
		Collect_How	+	FK
		Collect_Where	+	FK
		Collect_Package_What	+	FK
		Collect_Package_How	+	FK
		Collect_Transmit_How	+	FK
		Retrieve_Who	+	FK
		Retrieve_What	+	FK
		Retrieve_When	+	FK
		Retrieve_How	+	FK
		Retrieve_Where	+	FK
		Diagnose_Who	+	FK
		Diagnose_What	+	FK
		Diagnose_When	+	FK
		Diagnose_How	+	FK
		Diagnose_Where	+	FK
		Diagnose_Package_What	+	FK
		Diagnose_Package_How	+	FK
		Diagnose_Transmit_How	+	FK
		Use_Who	+	FK
		Use_What	+	FK
		Use_When	+	FK
		Use_How	+	FK
		Use_Where	FK	Text
User_Literature	=	Article_ID	+	PK
		{Article_Detail}		Long Integer
Article_Detail	=	ArticleName	+	Text
		Authors	+	Text
		Outcome	+	Text
		Journal	+	Long Integer
		Volume	+	Long Integer
		Country	+	Long Integer
		ImplementationLayer	+	Long Integer
		Purpose	+	Long Integer
		Disease	+	Long Integer
		Specialization	+	Long Integer

<u>Field</u>	<u>Field Components</u>	<u>Type</u>
CollectWho	+	Long Integer
CollectWhat	+	Long Integer
CollectWhen	+	Long Integer
CollectHow	+	Long Integer
Collectwhere	+	Long Integer
Collect_PackageWho	+	Long Integer
Collect_PackageWhat	+	Long Integer
Collect_PackageWhen	+	Long Integer
Collect_PackageHow	+	Long Integer
Collect_PackageWhere	+	Long Integer
Collect_TransmitWho	+	Long Integer
Collect_TransmitWhat	+	Long Integer
Collect_TransmitWhen	+	Long Integer
Collect_TransmitHow	+	Long Integer
Collect_TransmitFromWhere	+	Long Integer
RetrieveWho	+	Long Integer
RetrieveWhat	+	Long Integer
RetrieveWhen	+	Long Integer
RetrieveHow	+	Long Integer
RetrieveWhere	+	Long Integer
DiagnoseWho	+	Long Integer
DiagnoseWhat	+	Long Integer
DiagnoseWhen	+	Long Integer
DiagnoseHow	+	Long Integer
DiagnoseWhere	+	Long Integer
Diagnose_PackageWho	+	Long Integer
Diagnose_PackageWhat	+	Long Integer
Diagnose_PackageWhen	+	Long Integer
Diagnose_PackageHow	+	Long Integer
Diagnose_PackageWhere	+	Long Integer
Diagnose_TransmitWho	+	Long Integer
Diagnose_TransmitWhat	+	Long Integer
Diagnose_TransmitWhen	+	Long Integer
Diagnose_TransmitHow	+	Long Integer
Diagnose_TransmitWhere	+	Long Integer
UseWho	+	Long Integer
UseWhat	+	Long Integer
UseWhen	+	Long Integer
UseHow	+	Long Integer
UseWhere	+	Long Integer
DataUploadedBy	FK	Text

Appendix C – Database Diagrams

The ASP.Net database – The majority of the database is automatically generated. An additional table is added to store custom user information (custom_UserInfo). This information is displayed in the user profile page and can be edited by the user at any time.

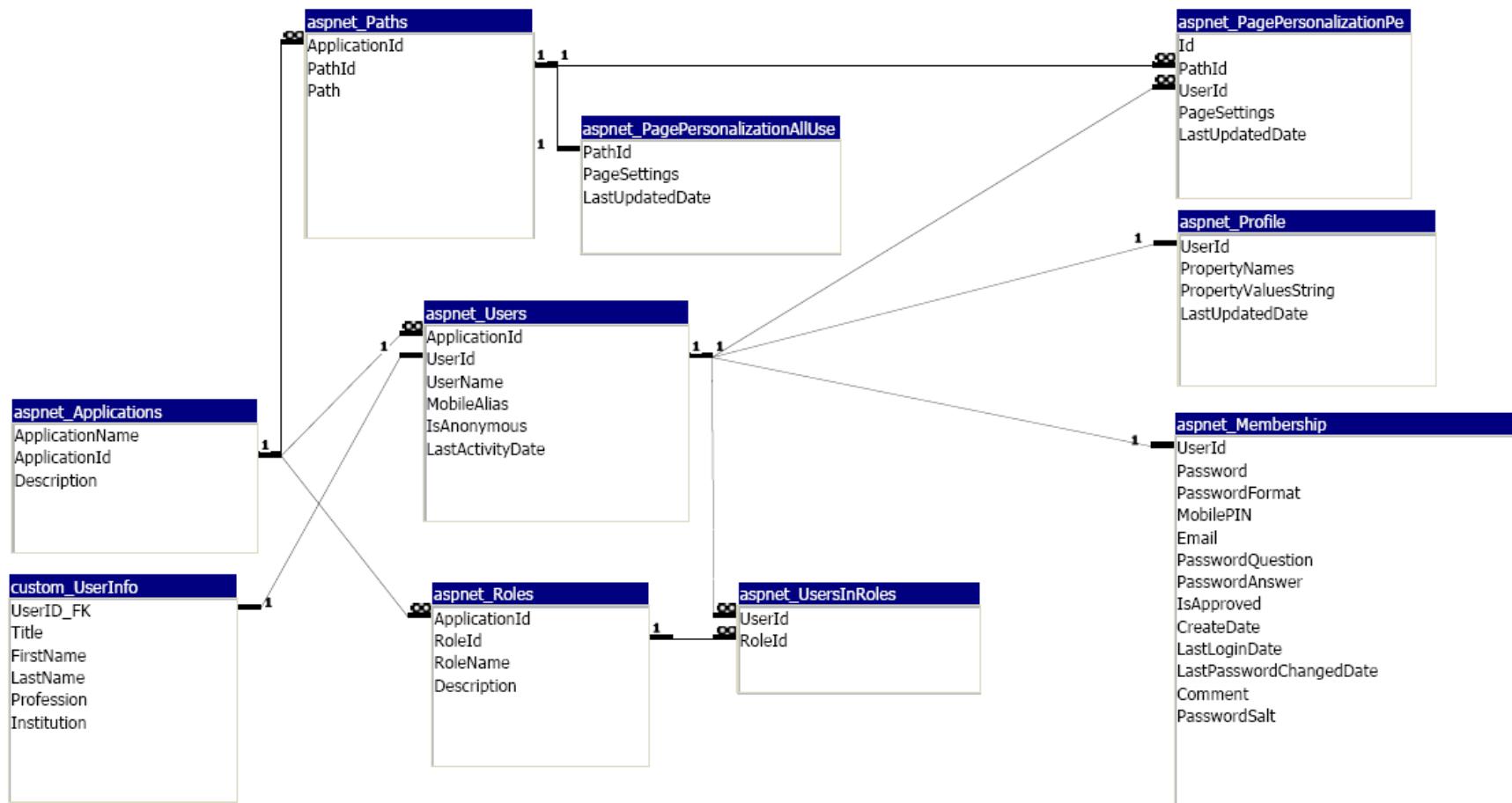


Figure C-1: ASP.Net Database Diagram

The Telemedicine Process Database –The initial database structure developed to store telemedicine project information. This database was used during the meta-study.

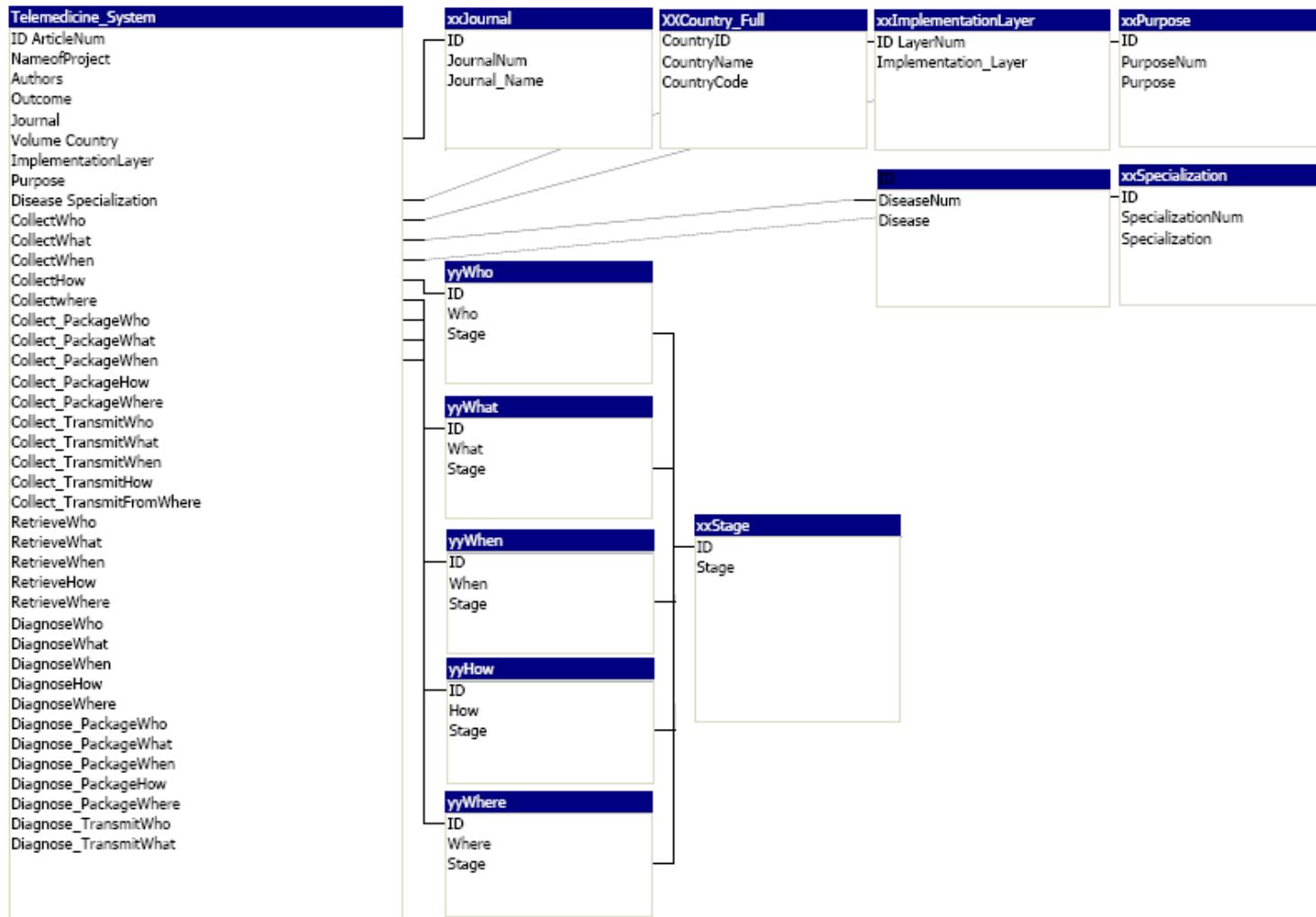


Figure C-2: The telemedicine process database diagram (used during the meta-study)

Final System Database – Includes the descriptive (Telemedicine_Project) and technical (Telemedicine_Process) data fields as well as the populated tables providing the information for the various drop down lists. A table to store project coordinates are also provided to store the location of the project. Users drag a marker on a Google map to select the location of the project.

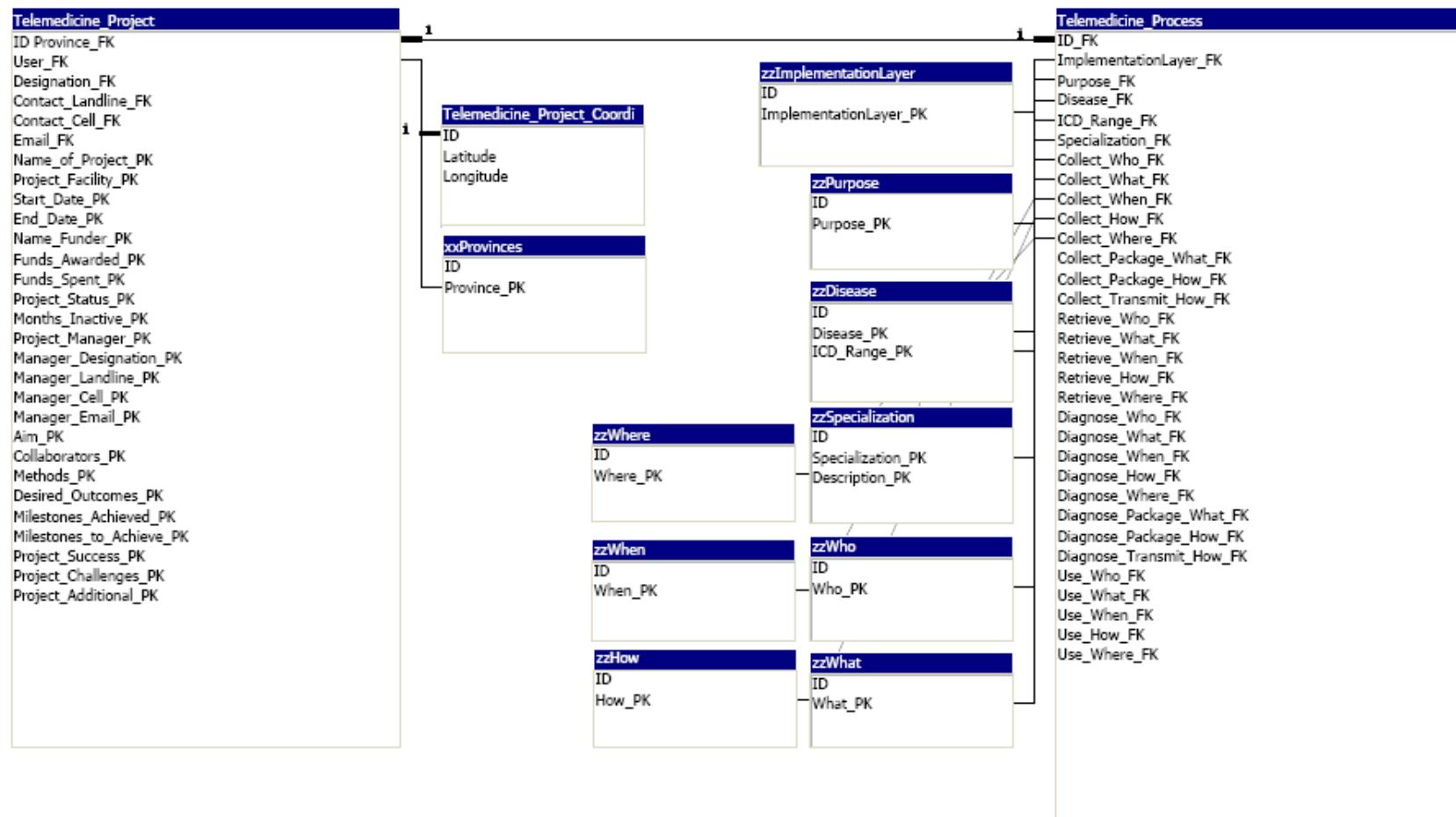


Figure C-3: Final information system database diagram

Appendix D – Information Collection Forms

The Telemedicine Process Data Collection Form – This form is used to document the telemedicine process during the meta-study. The refresh buttons allows the user to re-populate the information in the drop down field once information is added using another form.

NAVIGATION PANEL

- [View Articles](#)
- [Add Article](#)
- [Add "Journal"](#)
- [Add "Implementation"](#)
- [Add "Purpose"](#)
- [Add "Disease"](#)
- [Add "Specialization"](#)
- [Add "How"](#)
- [Add "What"](#)
- [Add "When"](#)
- [Add "Where"](#)
- [Add "Who"](#)

ADD TELEMEDICINE PROJECT TO DATABASE

Complete the form below to add your telemedicine project to the database.

Article Number:	<input type="text" value="103"/>
Name of Project:	<input type="text"/>
Authors:	<input type="text"/>
Outcome:	<input type="text"/>
Journal:	<input type="text" value="Journal of Telemedicine and Telecare"/> <input type="button" value="Refresh"/>
Volume:	<input type="text"/>
Country:	<input type="text" value="Afghanistan"/> <input type="button" value="Refresh"/>
Implementation Layer:	<input type="text" value="Business Case"/> <input type="button" value="Refresh"/>
Purpose:	<input type="text" value="Decision Support"/> <input type="button" value="Refresh"/>
Disease:	<input type="text" value="Ageing"/> <input type="button" value="Refresh"/>
Specialization:	<input type="text" value="Audiology"/> <input type="button" value="Refresh"/>
CollectWho:	<input type="text" value="Adult"/> <input type="button" value="Refresh"/>
CollectWhat:	<input type="text" value="Audiotmetric thresholds"/> <input type="button" value="Refresh"/>
CollectWhen:	<input type="text" value="Appointment"/> <input type="button" value="Refresh"/>
CollectHow:	<input type="text" value="Blood sugar monitor"/> <input type="button" value="Refresh"/>
CollectWhere:	<input type="text" value="Doctor's practice"/> <input type="button" value="Refresh"/>
CollectPackageWho:	<input type="text" value="Adult"/> <input type="button" value="Refresh"/>
DiagnoseWhere:	<input type="text" value="Call centre"/> <input type="button" value="Refresh"/>
DiagnosePackageWho:	<input type="text" value="Audiologist"/> <input type="button" value="Refresh"/>
DiagnosePackageWhat:	<input type="text" value="Alert"/> <input type="button" value="Refresh"/>
DiagnosePackageWhen:	<input type="text" value="At Completion of Previous Step"/> <input type="button" value="Refresh"/>
DiagnosePackageHow:	<input type="text" value="Central Database"/> <input type="button" value="Refresh"/>
DiagnosePackageWhere:	<input type="text" value="Call Centre"/> <input type="button" value="Refresh"/>
DiagnoseTransmitWho:	<input type="text" value="Audiologist"/> <input type="button" value="Refresh"/>
DiagnoseTransmitWhat:	<input type="text" value="Alert"/> <input type="button" value="Refresh"/>
DiagnoseTransmitWhen:	<input type="text" value="At Completion of Previous Step"/> <input type="button" value="Refresh"/>
DiagnoseTransmitHow:	<input type="text" value="1 Mbit/s ADSL"/> <input type="button" value="Refresh"/>
DiagnoseTransmitWhere:	<input type="text" value="Call centre"/> <input type="button" value="Refresh"/>
UseWho:	<input type="text" value="Consultant"/> <input type="button" value="Refresh"/>
UseWhat:	<input type="text" value="Alert"/> <input type="button" value="Refresh"/>
UseWhen:	<input type="text" value="After Completion of Previous Step"/> <input type="button" value="Refresh"/>
UseHow:	<input type="text" value="As Instructed"/> <input type="button" value="Refresh"/>
UseWhere:	<input type="text" value="Doctor's Practice"/> <input type="button" value="Refresh"/>
Data Uploaded By:	<input type="text" value="Webmaster"/>

Figure D- 1: The telemedicine process data collection form used during the meta-study

The Telemedicine Project Documentation Form – this form is used during the beta-test to register telemedicine project within a South African context on the system.

NAVIGATION PANEL

REGISTER NEW PROJECT

Use the form below to add a new project to the database.
 * Funds requested is only a rough estimate.
 * Not all fields are required. Provide any information you can.

Name of Province: Eastern Cape

User Completing Form: Webmaster

Designation: Masters Student

Email: alwynvzyl@gmail.com

Landline Number:

Cellphone Number:

Name of Project:

Project Facility Name:

Name of Funder/Donor:

Amount of Funds Awarded:

Amount of Funds Spent:

Duration of Project: (Optional)

Start Date of Project:						
<		August 2012			>	
Su	Mo	Tu	We	Th	Fr	Sa
29	30	31	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	1
2	3	4	5	6	7	8

End Date of Project:						
<		August 2012			>	
Su	Mo	Tu	We	Th	Fr	Sa
29	30	31	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	1
2	3	4	5	6	7	8

Status of Project: Active

Months Inactive:

Project Manager:

Designation:

Manager Landline:

Manager Cellphone:

Manager Email:

Collaborators:

Aim of Project:

Milestones Achieved to Date:

Milestones to be Achieved:

Success of Project to Date:

Challenges of the Project:

Any Further Information:

Figure D- 2: The telemedicine project documentation form

Revised Telemedicine Process Documentation Form – This form is used to add telemedicine process information to projects within a South African context.

PROCESS INFORMATION:

No process information has been uploaded for this project. Please complete the form below to add process information for this project.

Process Form:

Implementation Layer:	-Select--
Purpose:	-Select--
Disease Classification:	-Select--
ICD Code Range:	<input type="text"/> Get ICD Range
Specialization:	-Select--
Collect Who:	-Select--
Collect What:	-Select--
Collect When:	-Select--
Collect How:	-Select--
Collect Where:	-Select--
Package What:	-Select--
Package How:	-Select--
Transmit How:	-Select--
Retrieve Who:	-Select--
Retrieve What:	-Select--
Retrieve When:	-Select--
Retrieve How:	-Select--
Retrieve Where:	-Select--
Diagnose Who:	-Select--
Diagnose What:	-Select--
Diagnose When:	-Select--
Diagnose How:	-Select--
Diagnose Where:	-Select--
Package What:	-Select--
Package How:	-Select--
Transmit How:	-Select--
Use Who:	-Select--
Use What:	-Select--
Use When:	-Select--
Use How:	-Select--
Use Where:	-Select--

[Insert](#) [Cancel](#)

Figure D- 3: The revised telemedicine process collection form

Appendix E – Additional Information Requirements

Full List of Additional Information Required for a Project – This is the list of additional information fields as required by the Medical Research Council of South Africa. This information is incorporated into the information system after the alpha testing phase and is used during the beta testing phase of the project.

Additional information includes:

- Name of Province in which Project is Implemented
- User Completing Form
- Designation
- Email
- Landline Number
- Cell phone Number
- Name of Project
- Project Facility Name
- Name of Funder/Donor
- Amount of Funds Awarded
- Amount of Funds Spent
- Duration of Project
- Status of Project
- Months Inactive
- Project Manager
- Designation
- Manager Landline
- Manager Cell phone
- Manager Email
- Collaborators
- Aim of Project
- Methods
- Desired Outcomes of Project
- Milestones Achieved to Date
- Milestones to be Achieved
- Success of Project to Date
- Challenges of the Project
- Any Further Information

Appendix F – Mass E-Mail Content

Mass e-mail sent to potential users in the MRC's e-mail database.

The Medical Research Council and Stellenbosch University are conducting a census of Telemedicine and m-Health Projects in South Africa. The purpose of the census is to gather as much detailed information about Telemedicine and m-Health Initiatives in South Africa. This information will be made available to all interested persons that are registered with this platform, thereby disseminating valuable information which will aid in ensuring a more efficient and effective Telemedicine and m-Health ecosystem.

We will appreciate your time in registering as a member in the Telemedicine and m-Health network, this will not take longer than 5 minutes. Within 24hours of registering you will be sent a request to complete a project document form. Even if you don't have a project it would be advantageous to register as it will allow you access to the database of Telemedicine and m-Health Project.

Steps:

1. Click on the following link to register:
<http://academic.sun.ac.za/telemedSupport/Account/Register.aspx>
After the first form is completed you will be directed to a second form to add more detail about you. If you have a project to document, tick the check box and complete the form (all fields are **not** compulsory). This will give you access to the project registration form.
After you have completed both registration steps, you will be directed to your profile page.
2. If you have indicated that you have a project to register go to the Projects tab and select register new project in the navigation panel. Or click on this link:
http://academic.sun.ac.za/telemedSupport/FullMemberPages/Monitor_Form.aspx
You can register as many projects as you want. They do not have to be your projects. Any information will be sufficient; you do not need to complete the entire form.
After you have registered a project, the project should display in your profile page. You can click on the "To Project" link next to the project and edit the project information at a later stage.

IMPORTANT: If you do not see the project in you profile page after you have added it, please contact the webmaster ASAP at alwynvzyl@gmail.com or 14834340@sun.ac.za

Kind regards and looking forward to your participation

Alwyn Van Zyl
Telemedicine and mHealth
Medical Research Council

Appendix G – Results of Meta-Study

This is the complete results of the meta-study, presented graphically.

Table G-1: Figures illustrating the “Who” aspect of the critical inquiry

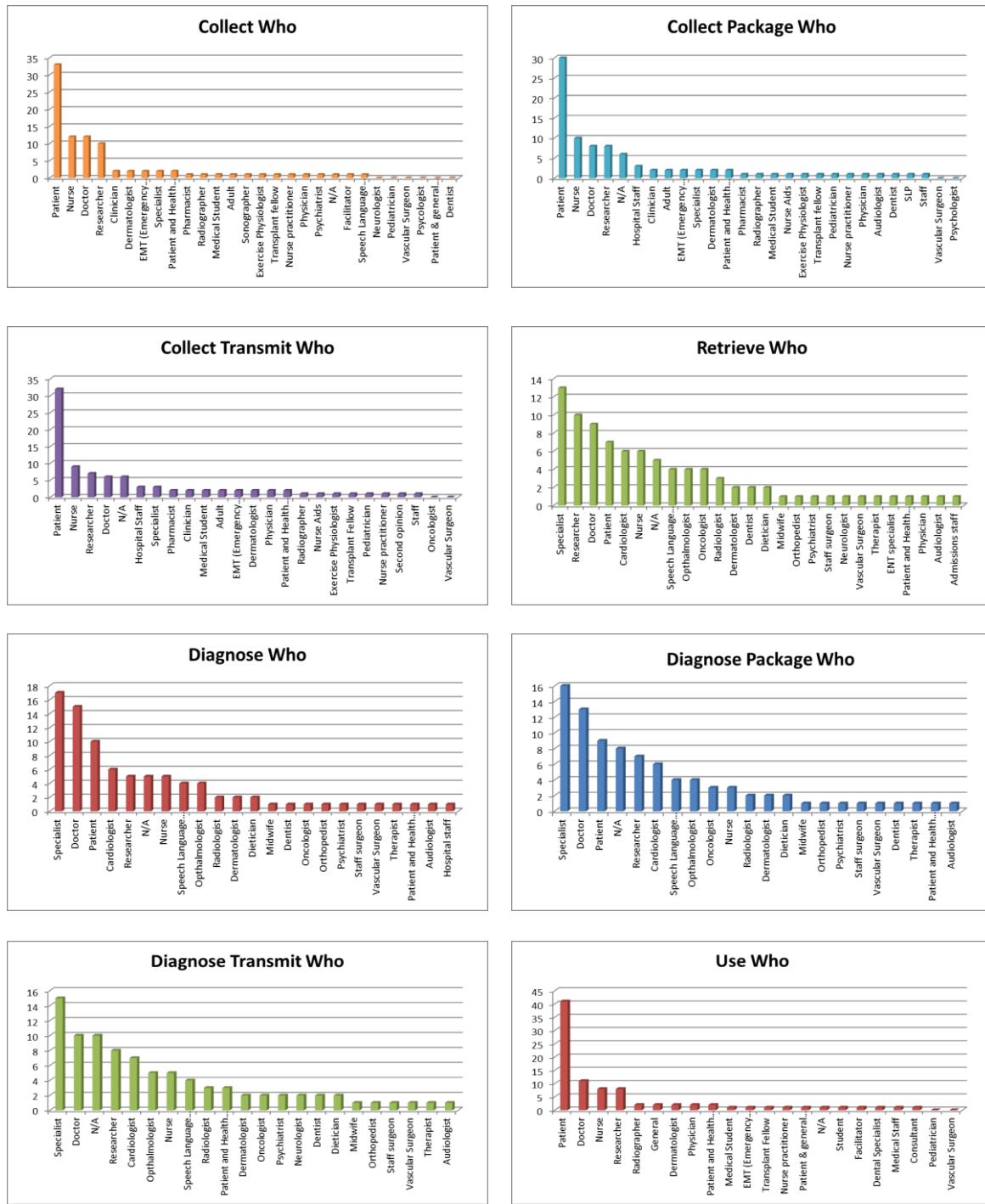


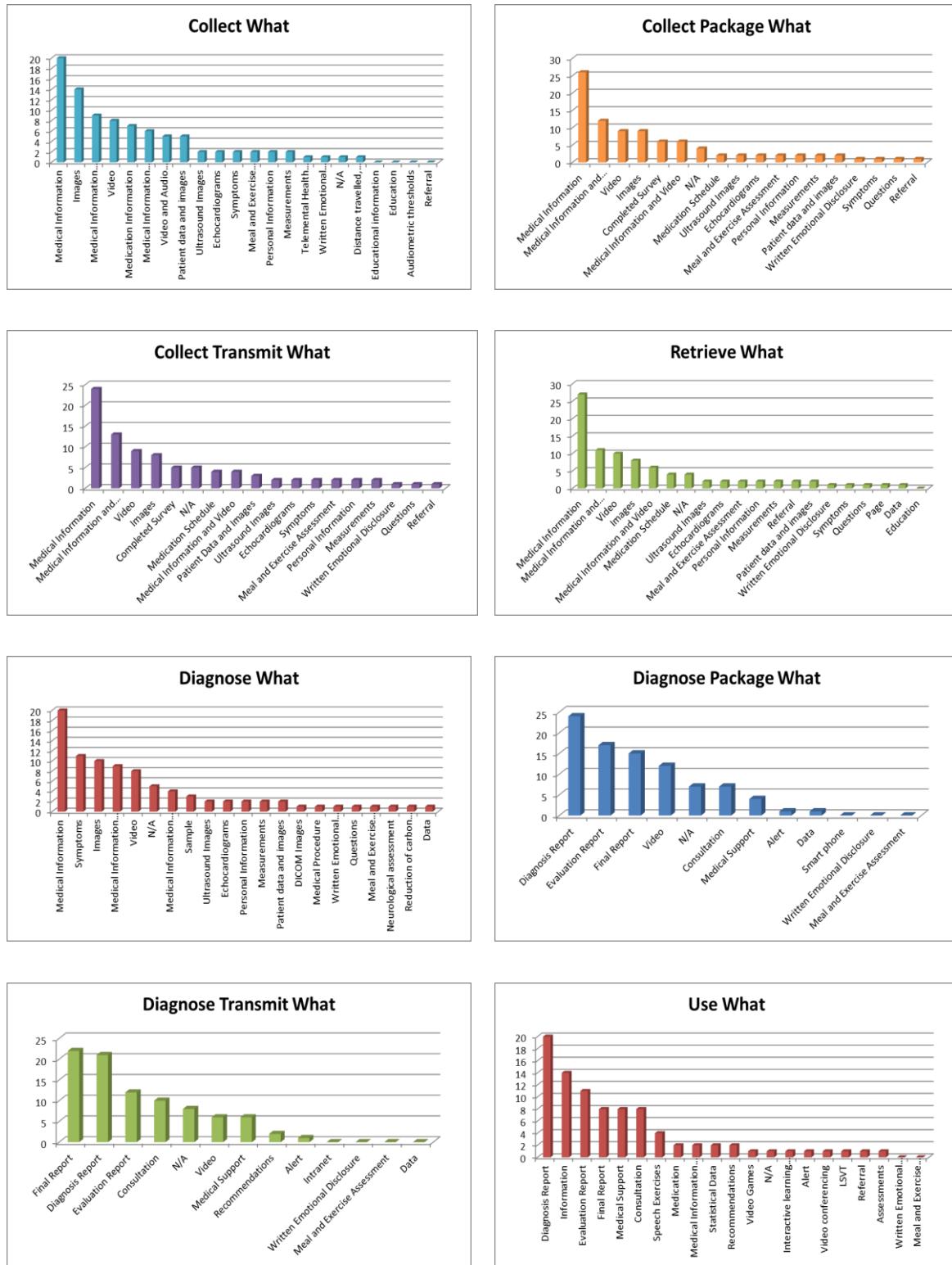
Table G-2: Figures illustrating the “What” aspect of the critical inquiry

Table G-3: Figures illustrating the “When” aspect of the critical inquiry

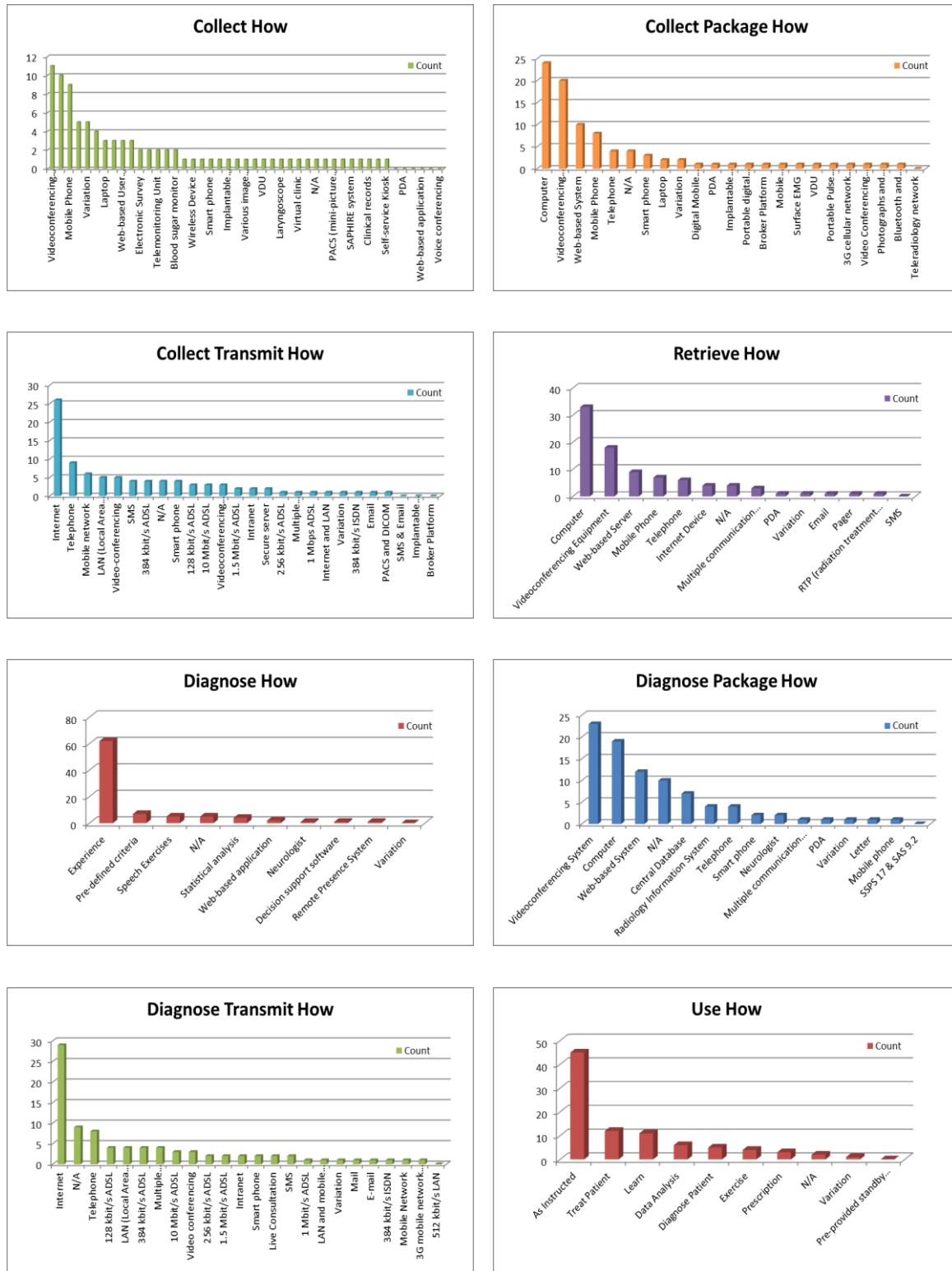
Table G-4: Figures illustrating the “How” aspect of the critical inquiry

Table G-5: Figures illustrating the “Where” aspect of the critical inquiry

Figure G-1 shows the diseases that were identified in the telemedicine projects documented during the meta-study. In general, no specific disease is targeted by a telemedicine project. The focus is generally on remote/specialist support.

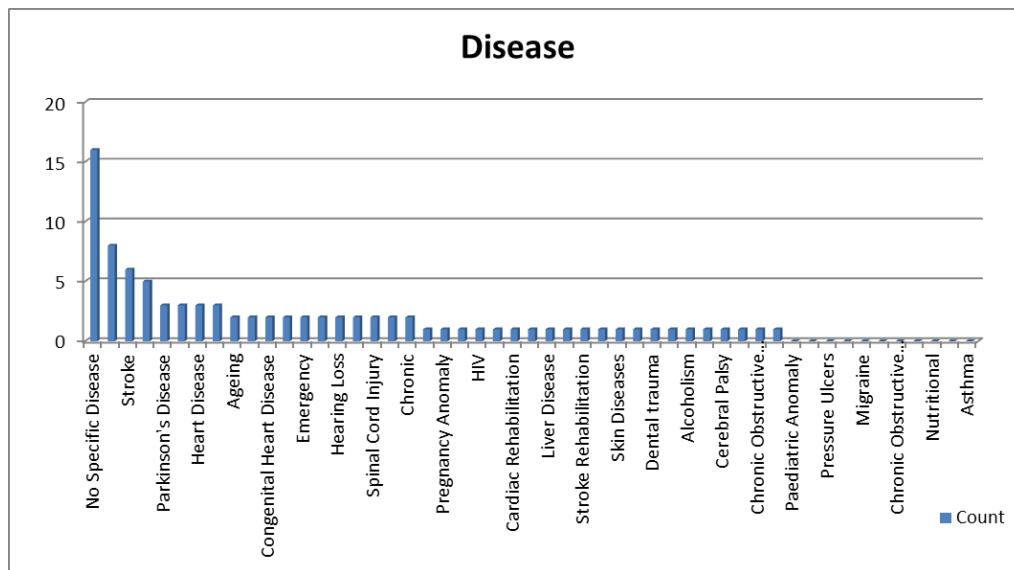


Figure G-1: Diseases encountered during meta-study

Figure F-2 shows the implementation layer of the telemedicine projects documented during the meta-study. The majority of telemedicine projects documented were of a temporary nature, as indicated by the top three results.

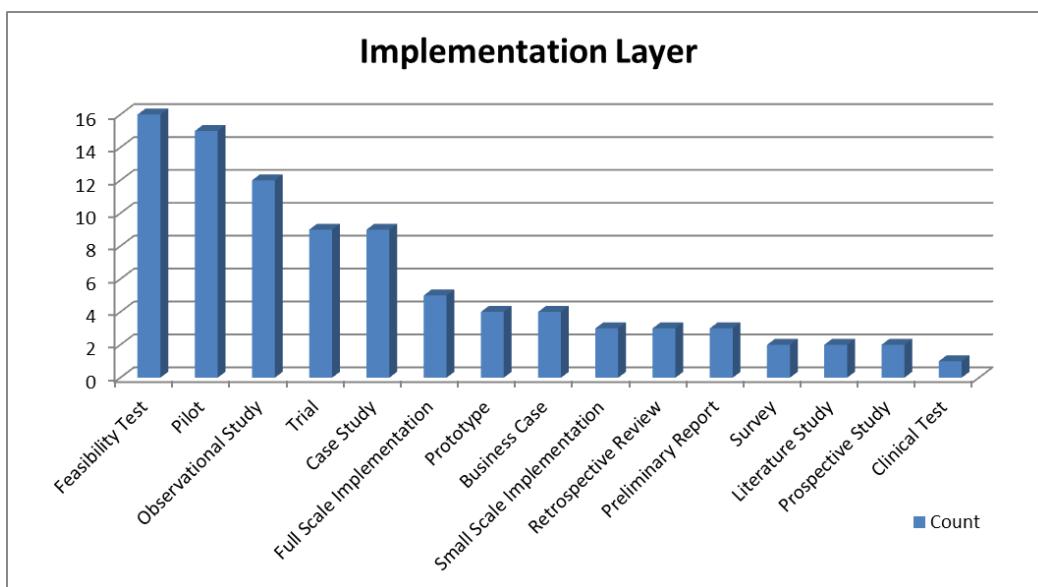


Figure G-2: Implementation layers encountered during the meta-study

Figure F-3 shows the purpose of the telemedicine projects documented during the meta-study. The majority of projects were of a support- and self-management nature.

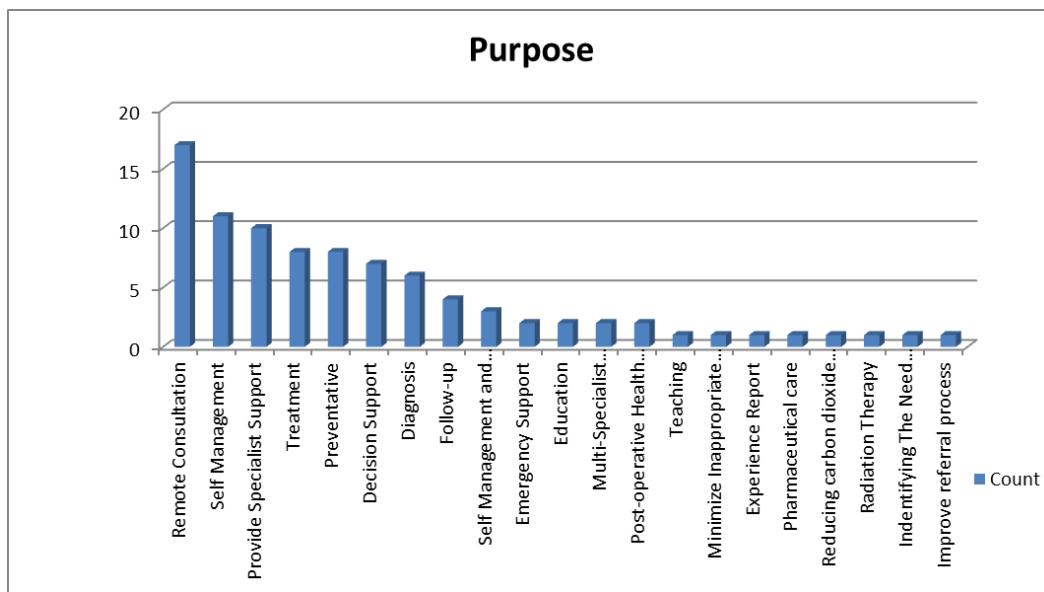


Figure G-3: The purpose of the telemedicine projects documented during the meta-study

Figure F-4 shows the specialisation/focus of the telemedicine projects documented during the meta-study. A wide variety of specialisation areas were identified during the meta-study, indicating that telemedicine is not limited to a certain type of specialisation.

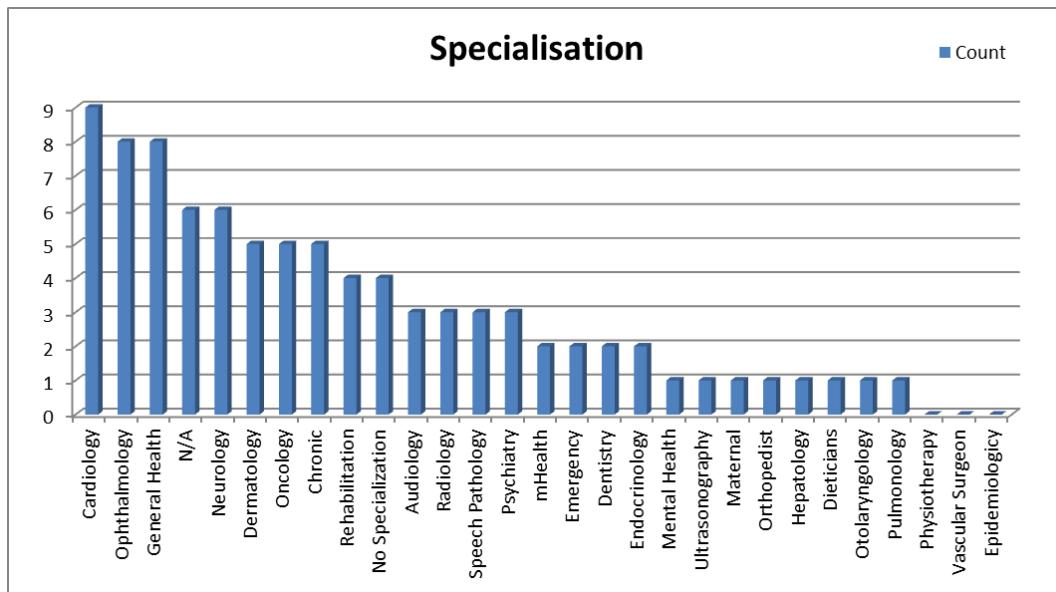


Figure G-4: The specialisation of the telemedicine projects documented during the meta-study