THE USE OF SPATIAL INFORMATION SYSTEMS IN THE MANAGEMENT OF HIV/AIDS: A STUDY OF GUGULETHU

By

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I hereby declare that this thesis is my original work and has not been submitted in any form to another university.

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Abstract

South Africa is experiencing an HIV/AIDS pandemic of shattering dimensions. The availability and provision of antiretroviral drugs could bring relief to the situation. Different patients use different antiretroviral therapies that vary in complexity of dosage and administering and monitoring the patient-medication related data are complicated tasks. The lack of physical infrastructure, lack of reliable statistics and the lack of adequate resources hinder the efficient management of HIV/AIDS.

The purpose of the study is to design and develop an HIV/AIDS database, which is embedded in a Spatial Information Management System. The functions of the system are to properly collect and administer HIV/AIDS related information and locate the HIV/AIDS patients and the proximity of these patients to existing infrastructure in view of providing a spur to improve health care service and delivery.

The pilot study area is the Gugulethu township in Cape Town where more than 27% of the 325 000 residents are HIV+. Microsoft® Access is the chosen software for the design of the HIV/AIDS database. Interfaces are customized where the user can view, sort, manipulate and retrieve accurate information on all patients, which has been collected by therapeutic counsellors. By integrating the database within a spatial information system it is also possible to combine patient information with geographic information such as the location of various health care centres and existing infrastructure.

It is shown that the implementation of the HIV/AIDS database and the Spatial Information Management System can play a critical role in determining where and when to intervene, improving the quality of care for HIV+ patients, increasing accessibility of service and delivering a cost-effective mode of information.

Table of Contents

List of Figures

Glossary

Antiretrovirals

Antiretrovirals drugs are used to treat infection with the human immunodeficiency virus (HIV), the virus that causes AIDS. These medicines cannot prevent or cure HIV infection, but help to suppress the virus to minimize secondary infections.

CD4 Cell Count

CD4 cell count assesses the state of the immune system. As the CD4 cell count declines, the risk of developing opportunistic infections increases. The normal range for CD4 cell counts is 800 to 1500 per cubic millimetre of blood.

Geocoding

Geocoding is the process of matching a common location identifier such as address, site location or building to a spatial and geographic database that contains the locations of streets, roads and the boundaries of administrative areas.

Spatial Information Systems (Geographic Information Systems)

SIS also referred to as Geographic Information Systems (GIS) is the branch of information technology that adopts computer-based technologies and methodologies to collect, store, interrogate, analyse, model, interpret and visualise spatially referenced information.

Therapeutic Counsellor

Therapeutic Counsellor also known as home-based carer is a peer counsellor trained to deal with immediate problems and crises, which relate as secondary diseases to HIV/AIDS. The individual also helps patients to examine issues, discover options and make decisions to enhance physical and emotional well-being with regard to antiretroviral therapy.

Abbreviations

AIDS	Acquired Immune Deficiency Syndrome
DBMS	Database Management System
E-R	Entity-Relationship
GIS	Geographic Information Systems
GPS	Global Positioning Systems
GUI	Graphical User Interface
HIV	Human Immuno-deficiency Virus
HIV+	HIV Positive
MIS	Malaria Information Systems
PIN	Permanent Identity Number
RDBMS	Relational Database Management System
SIS	Spatial Information Systems
SIMS	Spatial Information Management System
SMS	Short Message Service

1.0 INTRODUCTION

1.1 Background to the study

South Africa is experiencing an HIV/AIDS pandemic of shattering dimensions. Currently there are around 4.74 million HIV infections in the country and the South African Medical Research Council (MRC) projected that without appropriate treatment to prevent the development of AIDS, the number of AIDS deaths within the next decade would be more than double the number of deaths due to all other causes, resulting in 6 to 7 million cumulative AIDS deaths in South Africa in 2010 (Figure 1) [Medical Research Council of South Africa 2001].

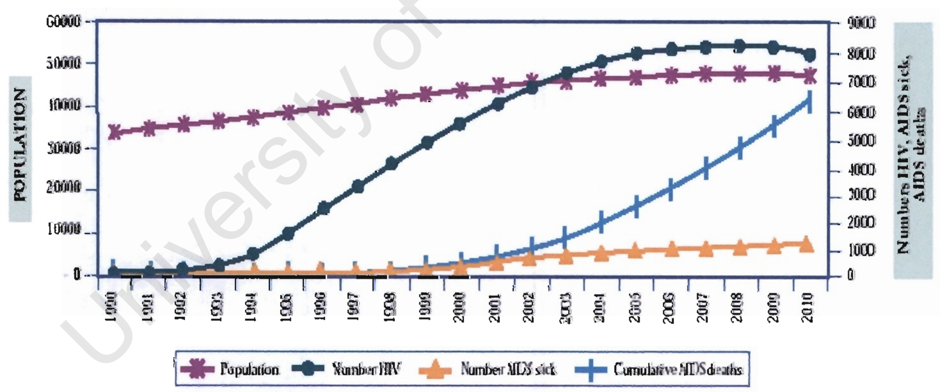

Figure 1: Projected numbers of people living with HIV, AIDS sick and accumulated deaths (thousands) [Dorrington et al. 2001].

According to the Actuarial Society of South Africa's 2000 model, the current South African HIV prevalence rate of 22.6% is amongst the most economically productive people, those between the ages 20 to 65 and recent predictions have shown that this rate will increase to 26% by 2005 [South African Business Coalition on HIV and AIDS 2002]. The high mortality and morbidity rate of HIV/AIDS means that no sector of the economy is immune to the impacts of the pandemic on the workforce, the level of productivity and the skills base. The social and economic impact of the disease demonstrates the need for careful prioritisation of intervention implying that HIV/AIDS is a priority of priorities [Medical Research Council of South Africa 2001].

In the midst of this crisis, treatment with antiretroviral drugs has resulted in a decline in the mortality rates [Whiteside, Sunter 2001]. Studies carried out by Reuter [2002] and Orrell [2002] reported that although they have seen great breakthroughs in the drugs available for treating persons with HIV disease, they believe that the mere provision of drugs is not an end in itself. Different patients use different antiretroviral therapies that vary in complexity of dosage and management of the administrative, medical and treatment data are complicated tasks.

The pandemic entails both a medical and a logistical challenge and as South Africa faces its renewal and renaissance, the only way to attain the vision of a democratic South Africa is by efficiently managing HIV/AIDS across the country. Leaving the medical challenge to the medical profession to overcome, engineers can contribute to the logistical challenge, which is based on managing health care using technology.

Management of HIV/AIDS in the context of this thesis encapsulates:

- The collection, recording and updating of patient-medication related data.
- The administering and monitoring of patient data.
- The registration and retrieval of accurate information of HIV/AIDS patients.
- The location of existing physical infrastructure.
- The examination of the spatial distribution of HIV/AIDS prevalence.
- The ability to contribute to decision-making and policy development.

The main challenges for an efficient and effective management of HIV/AIDS in South Africa are the inadequate physical infrastructure and the lack of reliable statistics on the disease. The data available are either estimates or projections and therefore range between educated guesses and wild speculation. The South African Government believes that the provision and supply of drugs to HIV/AIDS patients might be ineffective given the scale of the pandemic and its intersection with poverty and other epidemics such as Tuberculosis and Malaria. The lack of health centres, infrastructure and amenities (e.g. electricity and water) as well as low levels of treatment literacy are additional concerns for the required adherence rate of 95% [Orrell 2002]. Due to the limited resources of the country, there is a need to address the 'hot spots' first, which are areas with the highest HIV/AIDS prevalence.

Some of the data that is required to address the pandemic relates to:

- Location of high HIV/AIDS prevalence
- Level of infrastructure available to communities
- Infection rates of HIV/AIDS
- Status quo of medical care within communities

Most of this data is available in a number of systems. Municipalities will have data relating to the levels of infrastructure and the status quo of medical care. Doctors in the hospitals know how many patients with HIV/AIDS enter the clinic on a daily basis and when and how these patients were infected. The design of a system that combines this information needs to address the following two issues: firstly combining data that is being managed by various authorities in a number of systems and secondly combining data that is spatial and non-spatial in nature. The system should function as an information system containing accurate HIV/AIDS and infrastructure data and support decision-making and management. The easy integration of the system into existing GIS environments that are established within the governmental structures such as the Electricity Department, the Surveyor General's office, the Deeds Office and others is essential. The information obtained will then be turned into knowledge for use in efficient planning, evaluation and policy-making.

As the necessary physical infrastructure is not yet in place for an effective management of HIV/AIDS in South Africa, this study proposes the use of Spatial Information Systems (SIS) to provide a "virtual" infrastructure of support. This "virtual" infrastructure will consist of an HIV/AIDS database embedded in a Spatial Information Management System (SIMS). The functions of the SIMS are to properly administer and retrieve the patient-medication related data, assess 'hot' spots and the proximity of patients to existing infrastructure in view of providing an improved health care service.

In recent years, there has been a growing body of research emphasizing and reshaping the important role of Spatial Information Systems as tools in assisting health professionals and public health decision makers in view of improving the health status of communities. The contribution of SIS in disease control programs as an operational planning aid, or as a monitoring tool to assist with evaluation of control efforts, or as a research approach to investigate spatial associations of relevance to any disease epidemiology and control, has been discussed and described by many authors [Sweeney 1998, Kirby 1998, Foldy 1998]. SIS can perform several functions and fulfill many roles and the belief is that SIS may provide tremendous opportunities in HIV/AIDS patients' health informatics in South Africa.

While SIS cannot solve the HIV/AIDS pandemic across South Africa overnight, it should be seen as an innovative information-gathering tool that can be employed in the mobilization and response to the disease. The technology is regarded as a vehicle for facilitating public health planning and contributing to community-based decision-making and policy development. The tool would play a critical role in determining where and when to intervene, improving the quality of care for the HIV/AIDS patients, increasing accessibility of service and delivering a cost-effective mode of information [GIS in Health 1999].

The project aims to establish parameters and benchmarks relating to the use of SIS to administer and manage patient data and to locate the HIV/AIDS people and the existing infrastructure to improve health care service and delivery. The Gugulethu community in the Nyanga district in Cape Town was chosen as the study area (Chapter three) because an antiretroviral trial programme is currently being run involving the provision of medication to the HIV/AIDS patients. This thesis explores the use of SIS to develop a SIMS to facilitate information storage, processing and retrieval in a health set-up.

1.2 Objectives of the Study

This thesis can be divided into three sections, with the following objectives:

Objective 1: Design and Development of an HIV/AIDS database (Chapter 4)
Objective 2: Design and Development of a SIMS (Chapter 5)
Objective 3: Evaluation of the SIMS (Chapter 6)

The objectives translate into the following specific tasks:

- Collecting spatial and non-spatial data.
- Populating the HIV/AIDS database with non-spatial data.
- Integrating the HIV/AIDS database and spatial data into the SIMS.
- Giving a presentation to the prospective users and obtaining qualitative feedback and responses on the SIMS.

1.3 Assumptions

The author assumes that information technology infrastructure does exist at the clinic and that the level of computer literacy among the future users is adequate for the project. This is supported by a project in the research group investigating the feasibility of the technology in the Western Cape in South Africa.

The author agrees with the common medical view that HIV does in fact cause Aids. It is also assumed that the provision of drugs would result in a marked drop in deaths while making it possible for the patients to live a productive, healthy and fulfilling life with HIV. On the basis of these assumptions, the use of SIS is investigated as to how it can be employed as an information management tool to facilitate the administering of patient-medication related data, to assist in decision-making and to contribute to policy development.

1.4 Scope

The thesis focuses on the methods used to design and develop an HIV/AIDS database and a SIMS. The scope of the research is to investigate the use of Microsoft® Access and ArcGIS 8.2 in the management of HIV/AIDS. The HIV/AIDS database does not include a help function. The implementation of the system, the security aspects and the determination of costs of implementing the system fall outside the scope of this thesis.

The intention of this thesis is neither to carry out investigation concerning HIV/AIDS stigma and social discrimination nor to measure adherence.

1.5 Thesis Outline

The thesis consists of eight chapters. The flowchart below provides an overview of the structure and organisation of the dissertation.

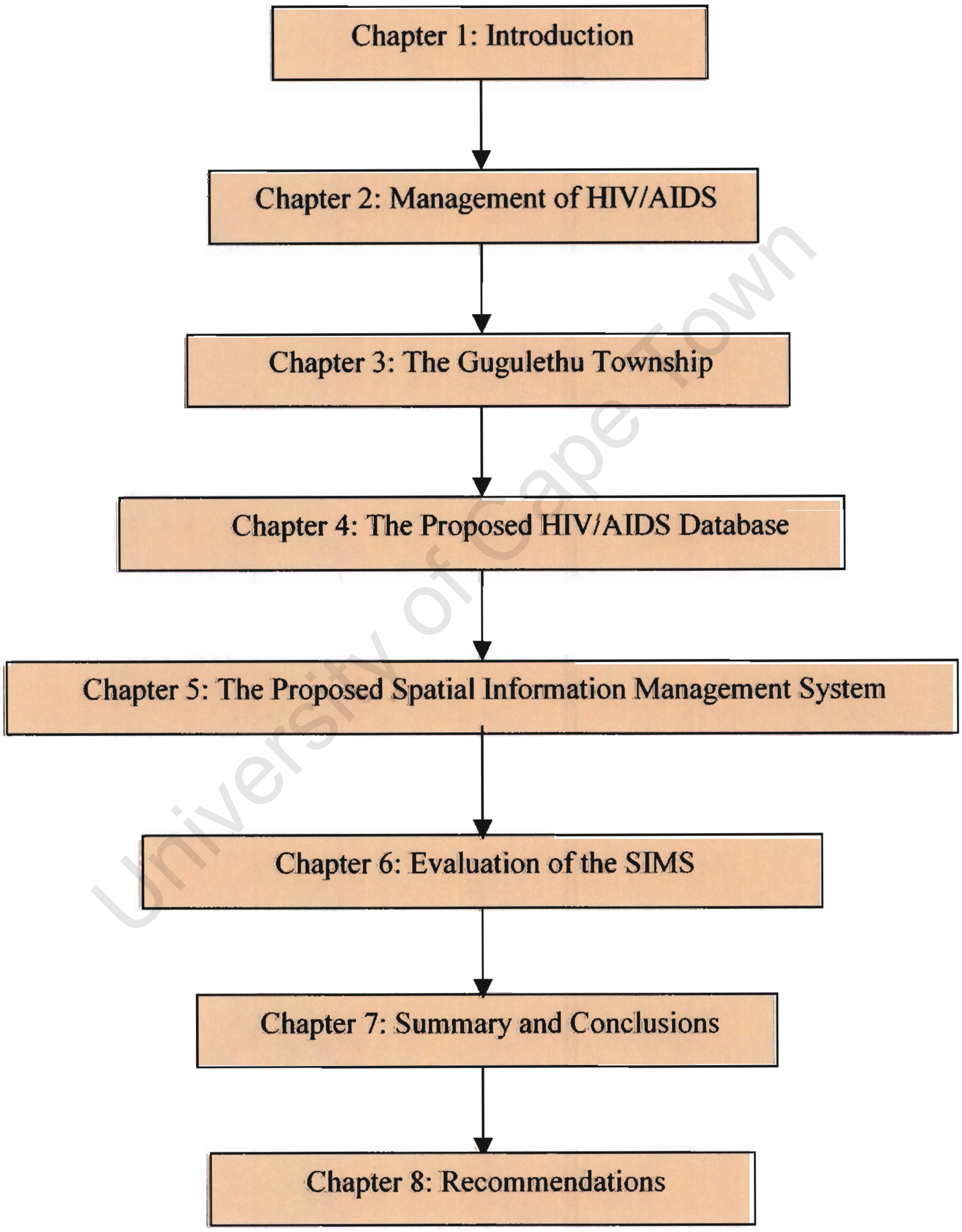

Figure 2: Chapter Overview

The first chapter provides the background to the study, its objectives, the assumptions and scope of the research and the thesis outline.

Chapter two reviews literature relating to similar projects relevant to this study and acknowledges the relevance of SIS in the health management framework.

The Gugulethu township is discussed in chapter three. This section features a brief history of the township, the infrastructure in place and the current HIV/AIDS statistics in the area. The Gugulethu community clinic and its method of collecting and filing patient data are also included. In addition, the need for an HIV/AIDS database is addressed.

The fourth chapter introduces the proposed HIV/AIDS database. The database development is thoroughly described and presented. The chapter also contains the information requirements analysis and the stages involved in the development of the proposed database. This section also features data acquisition, access and confidentiality.

Chapter five introduces the proposed SIMS, which could be utilised by health managers and decision-makers to efficiently manage HIV/AIDS in South Africa. This section emphasises the different stages involved in the development of the SIMS. The chapter then features the paradigm for the SIMS. The last section of the chapter, which focuses on the different functionalities of the SIMS, shows how the system can help in providing better health services and delivery thus contributing to health development.

The sixth chapter evaluates the SIMS. This chapter discusses the feedback and responses of the prospective users on the SIMS. Suggestions and concerns of the users are pointed out.

Chapter seven contains a summary of the study and draws conclusions regarding the developed SIMS and the final chapter provides recommendations for future research.

The appendices provide additional information relevant to the thesis. Appendix A presents the data form for collecting HIV/AIDS patient data at the Gugulethu HIV/AIDS clinic. Appendix B shows the HIV/AIDS patient data obtained from the UCT Lung Institute. Appendix C contains customised user interfaces for the proposed HIV/AIDS database.

2.0 USING SIS FOR THE MANAGEMENT OF HEALTH

2.1 Introduction

This chapter gives the reader a short review of the research work undertaken and explores the relevance of the dissertation. The first section places emphasis on the use of SIS for the management of health. The chapter continues by describing how GIS technology was used for the treatment of Tuberculosis in South Africa. In addition, the use of a GIS-based Malaria Information System for Malaria control in South Africa is presented. The chapter concludes with a discussion on the use of SIS for the management of HIV/AIDS in South Africa.

2.2 Using SIS for the Management of Health

One of the best ways to curb the spread of a pandemic is through efficient management of the disease as stated in Chapter One. Developing a system to manage HIV/AIDS across South Africa is a long-term undertaking, yet in the short term, parameters and benchmarks for possible treatment and management have to be established. The use of information systems in health management is not without precedent. The spatial dimension of health events and health services have long been recognized, dating back to 1854 when John Snow, a British physician, identified the source of cholera outbreak by plotting the locations of cholera deaths in central London [Bruder 1996, Loslier 1996]. Spatial analysis and the application of geographic information systems to health have been reviewed by several authors [Aboumrad et al. undated, Meert & O'Neill undated, Loslier 1996, Bretas 1996, Johnson & Johnson undated, Reissman et al. 2001, Green et al. 1998, Oranga 1996] and although found to be under-utilised it has been concluded that GIS has much to contribute to the health sciences.

Perceptions of what a management system can achieve varies and whilst there have been numerous critiques of the application of SIS technology towards aiding world health problems, it has first to be ascertained whether the technology is both applicable and sustainable in the South African setting. The HIV/AIDS problems in South Africa are unique and cannot be compared to those in developed countries and if SIS is to be used for the management of the pandemic, then it must respond to the realities and challenges of the disease within the South African context.

Tanser and Le Sueur [2002] stated that GIS in Africa is a tool of inherent potential for the management of HIV/AIDS as the spread of the disease is largely determined by environmental factors such as physical and socio-cultural environment, which vary greatly in space. Several studies involving the use of SIS in health systems have been conducted in South Africa and there is an encouraging amount of work in progress.

2.2.1 The Application of Geographic Information System technology for Tuberculosis Treatment in South Africa

In a study by Tanser and Wilkinson [1999], GIS technology was used to document and quantify improved access to Tuberculosis treatment through a community-based programme in Hlabisa, South Africa. Hlabisa health district is home to 210 000 largely Zulu people who rely on subsistence farming, migrant labour and pension remittances. The Tuberculosis Control Programme was first started in 1991 and available health system resources were used as treatment points, with nurses in village clinics and community health workers supervising treatment.

The study involved designing a Tuberculosis database and creating a Tuberculosis GIS. The database recorded all demographic, clinical and control programme management details including the location of supervision points and the number of patients supervised per year. Setting up the GIS entailed the digitisation of a series of geographical layers of the district. The location of the homesteads and the Tuberculosis treatment points in the district were positioned by Global Positioning System (GPS). The non-spatial tables generated from the database were then converted into MapInfo 5.0. Raster images of the supervision points taken in 1991 and 1996, and potential supervision points such as clinics, community health workers' homes, shops, churches, schools and hospitals were created in Idrisi 2.0. The analysis section of the project dealt with comparing the number of patients and the distribution of supervision points in 1991 to 1996. Average distances of homesteads to each supervision point in use in 1991 and 1996 were also compared and current potential supervision points were established. Figure 3 shows the treatment and supervision of Tuberculosis patients in Hlabisa district.

Tanser and Wilkinson [1999] believed that with recent advances in software and hardware, GIS is a cost-effective technology, which can be used to drive development and health care provision in South Africa. They further declared that GIS might help rational development of community-based care by providing maps, locating potential treatment points and focusing on areas of particular need.

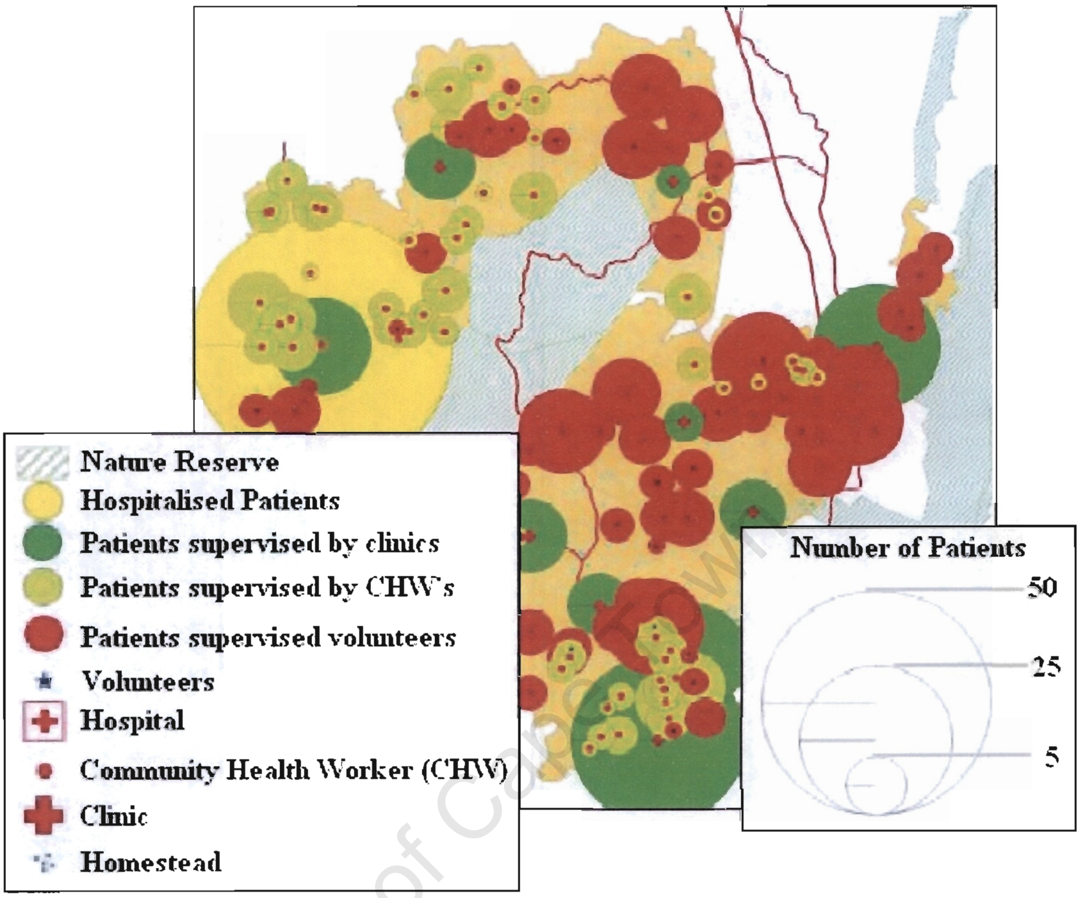

Figure 3: The Treatment and Supervision of Tuberculosis Patients in Hlabisa district. [Tanser and Wilkinson 1999]

2.2.2 The Use of a GIS-based Malaria Information System for Malaria Control in South Africa

Malaria is an environmental disease largely determined by rainfall and temperature. It occurs in the eastern low-lying regions of South Africa as a result of the climatic conditions. Inter-annual climate variations and the development of drug and insecticide resistance have resulted in an increase in case numbers. This highlights the need for accurate and timely data as well as an efficient information management system, which focuses on delivering appropriate control measures.

Responding to the need of relevant data to facilitate pragmatic decision-making, MIS (Malaria Information Systems) were developed for the malarious provinces of KwaZulu-Natal, Mpumalanga and the Northern Province in South Africa. Designing the MIS involved the collection of both spatial and non-spatial data. Non-spatial data such as population, name of family head, clinics and schools attended was collected manually by field officers and entered into the MIS. The latitude and longitude coordinates of all the homesteads (extended family household unit consisting of a number of dwellings) and other structures in the provinces were captured using GPS receivers. Each homestead is uniquely numbered according to its area and section number. Figure 4 below shows the conceptual model of the relational Malaria database. [Martin et al. 2002]

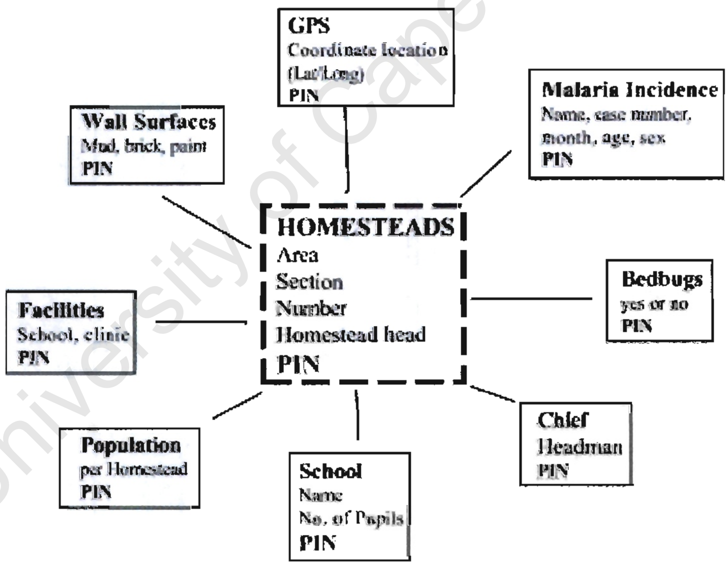

Figure 4: The Conceptual Model of the Relational Malaria Database

[Martin et al. 2002]

The core data table contains the homestead owners' name, address (area, sections and homestead number) and a unique PIN (permanent identity number) that is assigned to each homestead. This PIN is replicated in each of the tables to allow linking to the various data sets. The MIS was then integrated into GIS software to allow the automated production of thematic maps. The resulting maps have played an important role in formulating Malaria insecticide and drug policies, providing accurate information for tourists, planning water resource and infrastructural developments, evaluating changes in Malaria transmission over time and last but not least, allocating resources to control Malaria. Martin et al. [2002] concluded that the GIS-based MIS provides a decision support platform for the Malaria control initiative through the standardisation of data collection and reporting.

The above discussed projects demonstrate the value of GIS technology in health care and show that potential exists for SIS to play a role in rational and effective management of HIV/AIDS in South Africa. Both the Tuberculosis and Malaria studies show similarity to the proposed SIMS (Chapter Five) and share certain components worth illuminating:

- Capture of real-time patient data
- Overlay of existing infrastructure
- Visualisation of the 'hot' spots regions in perspective of health centres

The spatially referenced information about the location of HIV/AIDS people is an important part of the knowledge base requirement. This helps identifying areas, which are more prone to the pandemic. Layers of information can include distributions of all the elements thought to influence the spread of the disease for example: location of roads, location of health centres, location of main transport routes etc. Overlaying these distributions can provide indications of the factors associated with the spread of the pandemic and can support planning interventions either as preventive measures or by providing services to those already infected.

From a policymaking and planning perspective, accessibility to appropriate services such as community clinics or government hospitals can also be determined. Information of this nature can then be utilised to site services in locations and identify points of presence for particular HIV/AIDS treatment and prevention activity thereby minimising the distances that patients need to travel.

The studies show that the management of both Tuberculosis and Malaria thrive in the presence of well-constituted, effective information management systems. The performance of efficient information systems makes a profound difference to the quality and lifespan of the millions of people they serve. Motivation thus exists to undertake a study encompassing the use of SIS in the management of HIV/AIDS.

The review of health literature in South Africa shows that SIS holds promise for the management of HIV/AIDS. What makes SIS a viable tool for the management of HIV/AIDS is the ability to create simplified visual displays and to represent features from the real world which conveys information effectively to the users.

Believing that SIS technology will shed new light on the management of HIV/AIDS, this dissertation attempts to show how SIS can be used to properly administer and retrieve the patient-medication related data, locate the HIV/AIDS patients and existing infrastructure with the aim of providing better health service delivery and care.

The author draws on some of the findings and experiences reported in the literature discussed above, in order to design and develop an HIV/AIDS database and SIMS to address the previously mentioned concerns of data distribution and management. The Gugulethu community (Chapter Three) in the Nyanga district in the Western Cape province in South Africa serves as a pilot project to establish parameters and benchmarks that can be used for creating other such self-sustaining communities.

3.0 THE GUGULETHU TOWNSHIP

3.1 Introduction

The chapter will provide the reader with a brief background of the Gugulethu township focusing on the standard of living of the residents and the existing infrastructure. The HIV/AIDS pandemic within the community is also described. This section continues by discussing the Gugulethu community clinic and the challenges that the staffs are currently facing. The reasons why a computerised structure is required are also highlighted.

3.2 The Gugulethu Township

The Gugulethu township in the Nyanga district was established by the South African Government as an African area ten years after the Nationalist Party came to power in 1948. On the 14th November 1958, the South African government issued Notice No.1697, proclaiming a "Native Village on the outskirts of Cape Town". This location came to be known as Gugulethu meaning "Our Pride" in Xhosa [Ngcokoto 1989].

Gugulethu (see Figure 5) is situated about 20 km from Cape Town and is arguably one of the oldest and fastest developing black townships in South Africa. Gugulethu is home to approximately 325,000 people [Bekker 2003], generally poor as indicated by the averaged monthly income of R1126 [McDonald 2000]. A high unemployment rate, poor school system and inferior housing-conditions further exacerbate. The township displays a mixture of both formal and informal housing, with the latter usually belonging to new migrants.

Figure 5: The Gugulethu Township

It is important to note that the income and asset holdings of residents in the informal settlements are lower than those of residents living in the formal township of Gugulethu. Residents in the formal township have access to basic amenities such as water and electricity, while in the informal settlements, a common tap is shared by five to six families within the same vicinity and fire wood and paraffin are the predominant sources of fuels. The mode of transport for a significant proportion of the population is public transport, which is, used daily for commuting to work and to shops [Ebohon et al. 2000]. Through the years, the Gugulethu community has seen the construction and development of different infrastructure. The Nyanga Junction shopping complex, the information technology centre, the Ikhwezi community centre, the Siviyile tourism information centre and the Gugulethu community clinic were all built in view of enhancing the available services provided to the people [Countryman Media undated].

3.3 HIV/AIDS in the Gugulethu Community

The current HIV prevalence rate in the Gugulethu community is 27% [Bekker 2003]. This translates into ± 88,000 HIV/AIDS people and predominantly claims the lives of adults aged 19 to 40 leaving behind children and aging parents. Matoti [2003] declared that despite the existence of the Gugulethu community clinic, the inadequate infrastructure within the clinic put a strain on appropriate and efficient health care and service to the HIV/AIDS patients. A clinical drug trial known as the Sizophila project is being run at the clinic whereby 150 patients were selected to test antiretroviral treatment. One of the criteria to become part of the trial is that the CD4 cell count of the patient is less than 200, which indicates the final stage of HIV/AIDS. Matoti [2003] pointed out that if all the infected people in the Gugulethu community were to seek services from the clinic, this would cause a real management problem in terms of administering and monitoring the patient-medication related data. The low social economic background exacerbates the situation. The scale of the pandemic in the township is continuing to expand and as a result, the number of patients visiting the clinic is increasing. At the moment, only one doctor and one nurse deal with HIV/AIDS patients and it is sometimes impossible to attend to all patients coming in during a single day [Matoti 2003]. Therefore the concept of therapeutic counsellors was introduced. Such counsellors are HIV+ themselves and are on antiretroviral therapy, but are trained to understand the difficulties associated with taking antiretroviral drugs. This is done so that the counsellor can act as a peer supporter and provides information about the difficulties that come with antiretroviral therapy to patients. [Nxumalo 2003]. The task of the therapeutic counsellors is also to collect information regarding the patient's health, the medication, the adherence patterns as well as possible need for appointments. Magwa [2003] contended that a positive point worth noting is that the pandemic has challenged the community. Never before have syouths taken their parents to task over hitherto taboo subjects such as: sex, sexuality and traditional practices.

Moreover, an increasing number of the infected patients are openly declaring their status and are seeking medical help from the clinic without fear of social stigma. Matoti [2003] acknowledged that has been the trigger for community organisations and support groups to educate and promote awareness of the pandemic among the people. Various religious institutions in the community are also very active with HIV/AIDS campaign in the hope of bringing about behavioural change amongst the residents.

3.4 The Gugulethu Community Clinic

The Gugulethu community clinic as shown in Figure 6 below, runs a Hypertension clinic, a Diabetic clinic, an Asthma clinic, an Epilepsy clinic and, last but not least, an HIV/AIDS clinic all under the same roof.

Figure 6: The Gugulethu community clinic

In the early days of the HIV/AIDS clinic, the medical staff lacking in both knowledge and confidence were not able to take care of or counsel the patients.

But, after following mentorship programmes and by constantly keeping abreast of the effect and impact of the disease on people, the medical staff now find their jobs more rewarding. [Matoti 2003]. However, a number of administrative challenges still need to be addressed.

3.4.1 Challenges currently being faced at the Gugulethu Community Clinic

One of the main challenges that the staffs are still struggling with is the current paper-based management system of HIV/AIDS patient data. Magwa [2003] revealed that the task involves complicated administrative procedures at the cost of long working hours. Each patient visiting the HIV/AIDS clinic has a folder comprising of personal information including name, address, next of kin. Clinical information for example height, weight, blood group, type of disease are also recorded (see Appendix A). At each visit, respective folders for the patients are retrieved and entries are made in the patients' file by either the administrative clerk or the nurse. General comments about the patients' well being are recorded by the physician. In view of easing the lives of the infected patients and avoiding long queues at the dispensary, the patients are examined and dispensed with the appropriate medications in the physician's consulting room itself.

Matoti [2003] explained that the process of looking into each patient's file, understanding how they are reacting to the prescribed medications, monitoring their adherence patterns, dispensing the medications and finally giving them further advice and encouragement, requires much patience and dedication. He also argued that as the registration, consultation and dispensing processes are carried out manually, human errors such as misplacing or losing the folders are bound to occur. Having to look for folders, search for information for a particular patient, replicate it and annex the information, Magwa [2003] found this paperwork both frustrating and draining.

In addition, Matoti [2003] stated that it is common factor that patients who feel they are not benefiting from the health care and service that is being provided, will opt to go to another health centre. Several cases of patients transferring to other health centres or even patients from elsewhere coming for treatment at the Gugulethu community clinic have been registered. The main drawback in such cases is that the patients' health history is unknown and it is then up to the physician to work through the patients' health pattern. Matoti [2003] pointed out that in such circumstances, a distributed computer system that supports authenticated access to different health centres would provide immediate access to patients' details. This will aid swift diagnosis of the disease and ensure quicker and more effective treatment. He further added that paper files are not the most efficient or fastest means of gathering and analysing data and these inefficiencies are more apparent as the number of patients visiting the clinic increases. He reasoned that keeping the data in digital format will help the space requirement factor and will facilitate access to and distribution of the patient-medication related data, to and from different health centres.

Another concern expressed by the staffs is that health officials and managers have little access to Gugulethu and in such instance they are barely aware of the medical, infrastructural and working conditions at the community clinic. Matoti [2003] reasoned that for the Gugulethu community clinic to undergo any upgrading to the infrastructure, it must first and foremost be visible on the South Africa health centres map. He further stated that health officials and managers must be made aware that over 27% of the inhabitants in Gugulethu are HIV+, that the people are struggling with the pandemic in the context of extreme poverty and that the poor existing infrastructure at the clinic hinder the delivery of efficient health care and service.

3.4.2 The Need for a Computerised Structure

The need for a system, which will support data collection, recording and updating, has become very apparent. The problems, which the staffs at the Gugulethu community clinic face daily, and the increasing complexity of health care as HIV/AIDS becomes more prevalent, has highlighted this need. The author proposes an HIV/AIDS database (Chapter Four) that will facilitate the task of filing and monitoring patient data. By keeping all the patient records digitally, information retrieval will no longer be a tedious task of looking through paper records. The function of the database system is to allow physicians access to their own patient records and information about any record would only be transmitted to other physicians if explicitly requested. As stated in section 3.4.1, since the patients change their physicians from time to time, the HIV/AIDS database will offer a unique way to provide a complete patient history. The database will be designed in such a way that it captures the common structure of patient-medication related information, which will enable the sharing of data across different health centres.

The HIV/AIDS database can also be integrated into an SIMS (Chapter Five) whereby location of patients can be viewed in perspective of the health centres. The SIMS will geographically locate personal health data through a geocoding process enabling health officials and managers to be aware of the HIV/AIDS situation in underprivileged areas. The georeferencing of personal health data will allow the examination of the spatial pattern of HIV/AIDS and enhance the decisions made by health officials and managers. The ability to develop relevant, accessible and useable SIS and health data maps for communities is an important step toward enabling individuals to improve their health and increase their control over it.

The introduction of SIS and information technology at the Gugulethu community clinic will change the existing method of managing HIV/AIDS patient data. The shift from a paper-based system to a computerised system is usually rejected by those unfamiliar with the technology and can easily result in non-cooperation. Prior to implementing the system, important issues need to be addressed for the system to be an effective data store that carries the confidence of its users. Intensive training sessions should be provided to the future users to familiarise themselves with the different functionalities of the HIV/AIDS database and SIMS. The sessions will have to be accommodated within the already busy schedules of the physicians. The success of the system will depend on the future users; therefore it is their enthusiasm and commitment that will see the project overcome the inevitable stumbles and setbacks. Legal and professional standards must also be revised to specify appropriate new roles and responsibilities associated with the shift from the paper chart to the HIV/AIDS database and SIMS.

Patient privacy is another important issue and with highly sensitive data such as HIV/AIDS status, drug records etc, it is crucial to find ways to ensure that confidential electronic health information is not divulged. It is important to allow access to the HIV/AIDS database and SIMS only to those with a need to know and to certify their identity before permitting access. In addition, to assure patients that strict confidentiality is being maintained and measured, the system must provide different levels of data confidentiality as required for its various users.

This chapter has reviewed the Gugulethu township and discussed how the residents are dealing with the HIV/AIDS pandemic. The chapter continued by featuring the need for a computerised structure at the Gugulethu community clinic. This section leads to the proposed HIV/AIDS database for the management of patient-medication related data.

4.0 THE PROPOSED HIV/AIDS DATABASE

4.1 Introduction

This chapter proposes HIV/AIDS database, which offers a solution to the Gugulethu HIV/AIDS clinic to record, maintain and monitor information about HIV/AIDS patients. The chapter begins by addressing the stages involved in the development of the proposed database. This section also features data acquisition, access and confidentiality.

4.2 The Database Development

The aim is to design and develop an HIV/AIDS database in view of facilitating the collection, storage, processing and retrieval of patient-medication related data.

The database design process involves the following phases:

- Information Requirements Analysis, which is the collection of data related to the prospective users of the database.
- Conceptual Modelling, which involves interpretation of the user needs and the development of a conceptual schema.
- Logical Modelling, which implies the mapping of the conceptual schema into the data model of the database management system (DBMS).
- Physical Modelling, which entails the specification of storage structures and paths.
- Implementation of the database. [Yirenkyi 2000]

4.2.1 Information Requirements Analysis

As reviewed in Chapter Two, information systems can provide tremendous potential in supporting HIV/AIDS management, but the design, development and implementation of the database are complex and non-trivial tasks. An important step in trying to address this complexity is the information requirements analysis, which involves two phases:

- User requirements analysis
- Data requirements analysis

The two phases were established through the intensive and iterative process of meetings, interviews and personal communications among physicians and health managers.

4.2.1.1 User Requirements Analysis

The user requirements analysis necessitated taking into consideration the following points:

- Who are currently involved in the filing and monitoring of the patient-medication related data?
- Who are the prospective users of the HIV/AIDS database?
- What is the level of computer literacy of the prospective users?
- What are the user needs?
- What outputs must be generated by the HIV/AIDS database?

The intended users of the database were identified as being the physicians, the registered nurses and the administrative clerks. The identified users showed much interest in the introduction of a database and believed that a computerised system will ease the workload and address the shortcomings of the current paper-based system. The database must cope with the various operations of the management of HIV/AIDS patients, which will involve the editing of new records of patients, the viewing of existing information and the monitoring of the patient-medication related data. As an option concerning the provision of effective and efficient health services to the patients, the users expressed the need for a database which is easy to use and work with, and operative. The prospective users suggested that training sessions in computer literacy be provided.

4.2.1.2 Data Requirements Analysis

The data requirements analysis is the most difficult and complex phase and addresses critical issues namely:

- Understanding the user needs which involves seeing the bigger picture from a medical point of view.
- Reviewing the current paper-based management system of HIV/AIDS.
- Identifying the relevant data and their characteristics.
- Translating the relevant fields of data from the paper-based management systems (see Appendix A) to the computerised system.
- Understanding the cross disciplinary aspect of the management of HIV/AIDS between the database designer and the users.

4.2.2 Conceptual Modelling

The conceptual modelling phase of the design process embodies a clear interpretation of the user needs and data requirements. The conceptual model describes the objects of interest, often called entities together with the relationships between them. In relation to this study, Chen's E-R model will be used to design the HIV/AIDS database model. In practice, the term "entity" refers to the rectangle in an E-R diagram. Figure 7 below shows the conceptual model of the relational HIV/AIDS database with all the different entities namely Patient, Adherence Report, Viral Load etc.

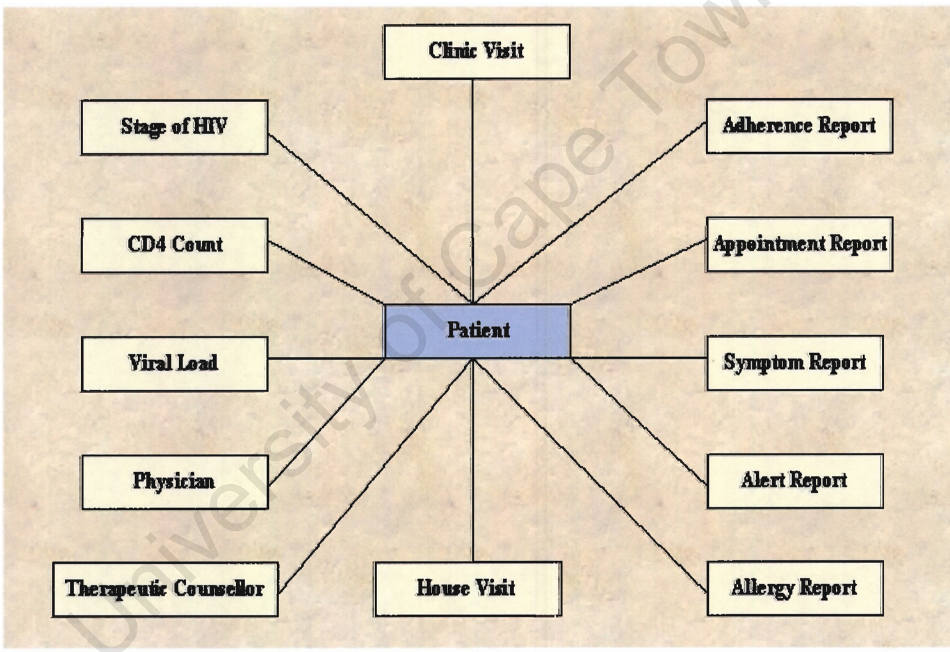

Figure 7: The Conceptual Model of the Relational HIV/AIDS Database

The circles connected to the rectangle are the attributes of the entity. Figure 8 below shows an E-R entity, where Patient is the entity and PatientID, Surname, Name, Street, Suburb, Erven, Telephone, Cell, Gender and DateofBirth are the attributes.

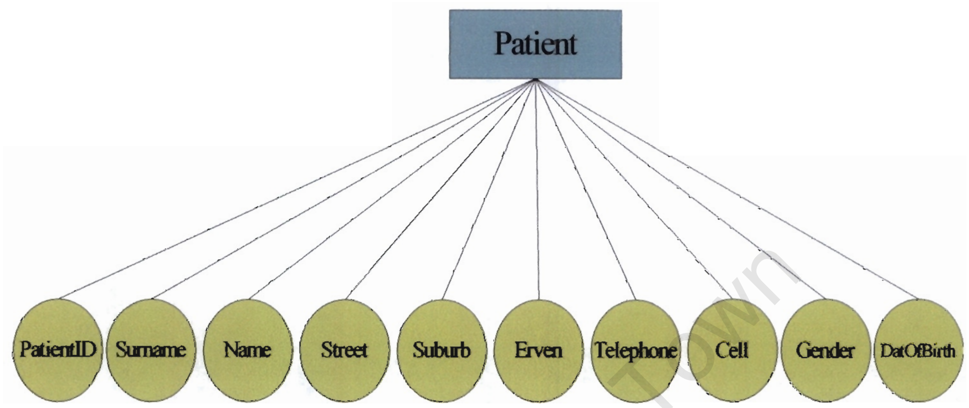

Figure 8: Entity and its Attributes

Relationships show how each entity connects, relates and interacts with other entities. Figure 9 shows a 1:M relationship between the TherapeuticCounsellor entity and the HouseVisit entity because one therapeutic counsellor can go for many house visits.

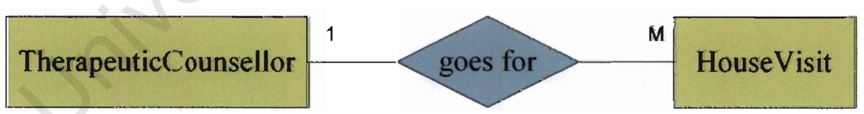

Figure 9: A Relationship between Two Entitiess

During the different house visits, the therapeutic counsellor collects information regarding the patient's health, the medication, the adherence patterns as well as possible need for appointments. This information is transferred to the database via SMS (Short Message Service) technology using a cell phone. Figure 10 shows the different menus on the cell phone facilitating the collection of data.

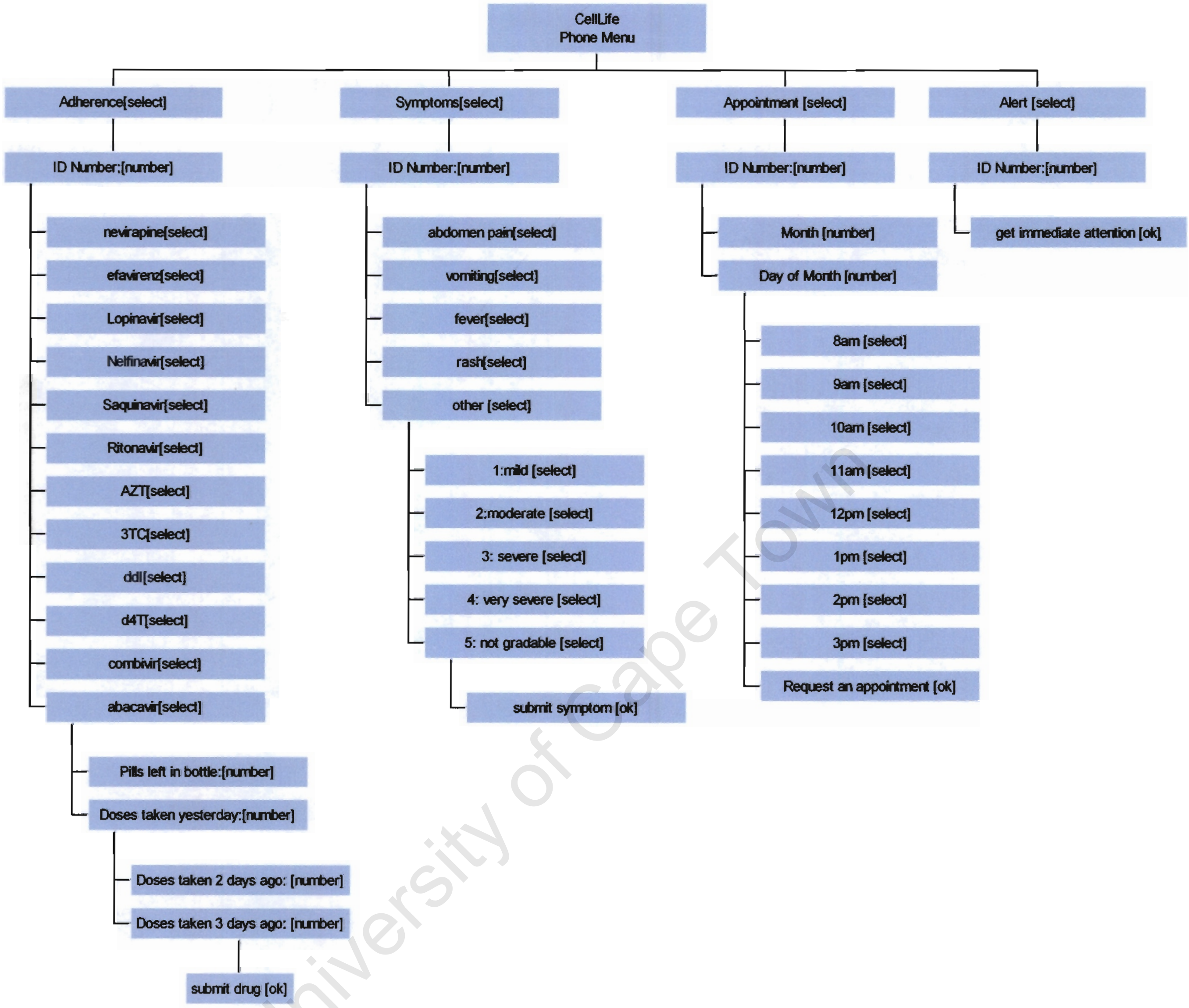

Figure 10: The Different Menus on the Cell Phone [Rivett 2003].

The menus were translated into entities while the different options within the menus were translated into attributes. The entities and attributes listed in Figure 11 were used in the design of the HIV/AIDS database. The underlined attributes are the primary keys while the attributes in italics are the foreign keys.

Entities	Attributes
AdherenceReport	DrugID, *HouseVisitID, ClinicVisitID*, DrugType, DrugType2, DrugType3, PillCount, OneDayAgo, TwoDaysAgo, ThreeDaysAgo, DosingInMg, DrugSideEffect, SideEffectStarted, SideEffectEnded
AlertReport	AlertID, *HouseVisitID, ClinicVisitID*, Description
AllergyReport	AllergyID, *ClinicVisitID*, AllergyType, Comment
AppointmentReport	AppointmentID, *HouseVisitID, ClinicVisitID*, DateOfAppointment, ReportTime
CD4Count	CD4CountID, *ClinicVisitID*, AmountInCellsPerMicrolitre
ClinicVisit	ClinicVisitID, *PatientID*, PhysicianID, DateOfClinicVisit, ReportTime, Diagnosis, PatientWeight
HouseVisit	HouseVisitID, *PatientID*, TherapeuticCounsellorID, DateOfHouseVisit, ReportTime
NextOfKin	NextOfKinName, Street, Suburb, Telephone, Cell
PatientClinicalInfo	ClinicalID, *PatientID*, Height, Weight, BloodGroup, StartOfTreatment, DisclosureOfStatus, IsPatientPregnant, TBStatus, ChestXRBaseline, DateOFChestXR, VDRLStatus
PatientFinancialInfo	FinancialID, *PatientID*, OccupationStatus, IncomePerMonth, NumberOfChildren, NumberOfEconomicDependents, NumberOfAdultsInTheHousehold,NumberOfChildrenInTheHousehold
PatientMedicalHistoryInfo	MedicalHistoryID, *PatientID*, DateOfPositiveTest, PlaceOfDiagnosis, DateOfLastNegativeTest, ProbableRouteOfInfection, PreviousTb, IsPreviousTBFullyTreated, DateOfLastPapSmear
PatientMiscellaneousInfo	MiscellaneousID, *PatientID, NextOfKinName*, RelationshipStatus, WithPartnerDuration, LanguageSpokenAtHome, SecondLanguage, LevelOfEducation
PatientPersonalInfo	PatientID, Surname, Name, Street, Suburb, Erven, Telephone, Cell, Gender, DateOfBirth
Physician	PhysicianID, PhysicianSurname, PhysicianName, Building, Street, Suburb, PostalCode, Department, Telephone, Cell
TherapeuticCounsellor	TherapeuticCounsellorID, TherapeuticCounsellorSurname, TherapeuticCounsellorName, Street, Suburb, Erven, Telephone, Cell
SymptomReport	SymptomID, *HouseVisitID, ClinicVisitID*, SymptomType, Severity
StageOfHIV	StageOfHIVID, *ClinicVisitID*, StageOFHIV
ViralLoad	ViralLoadID, *ClinicVisitID*, AmountInCopiesPerMillitre

Figure 11: Entities and Attributes in the HIV/AIDS Database

The AdherenceReport entity contains the following attributes:

- DrugID is the primary key.
- *HouseVisitID* is the foreign key.
- *ClinicVisitID* is the foreign key.
- DrugType, DrugType2, DrugType3 are the combination of antiretrovirals.
- PillCount is the total number of pills in the pillbox.
- OneDayAgo, TwoDaysAgo, ThreeDaysAgo determine the adherence of the patient to the prescribed medications.
- DosingInMg is the number of times the combination of pills must be taken.
- DrugSideEffect relates to any side effect of the drugs being taken.
- SideEffectStarted, SideEffectEnded specify the dates when the side effect started and ended.

The most desirable database design involves slim tables rather than fat ones, hence the reason for splitting the numerous details of the HIV/AIDS patients into five entities namely: PatientPersonalInfo, PatientMiscellaneousInfo, PatientClinicalInfo, PatientFinancialInfo, PatientMedicalHistory. Entities CD4Count, ViralLoad and StageOfHIV contain quantitative data that help in monitoring the health pattern of patients.

4.2.3 Logical Modelling

Logical modelling is the process of transforming a conceptual data model into a relational data model by translating each entity in Figure11 (Pg 44) into a table with its respective attributes. The relational data model includes two main types of constraints whose purpose is to maintain the accuracy and integrity of data in the database. These constraints are known as entity integrity and referential integrity. The entity integrity assures that every relation has a primary key and that the data values for that primary key are all valid. In particular, it guarantees that no primary key attribute is null. Referential integrity requires that a relational database management system (RDBMS) keeps each foreign key consistent with its corresponding primary key. The referential integrity rule states that either each foreign key value must match a primary key value in the other relation or else the foreign key value must be null.

Defining the relationships between the different tables involves understanding the flow of data entry in the tables. Figure 12 shows that when the patient goes for a clinic visit, the tables AdherenceReport, AppointmentReport etc are updated. The relationship between the Patient table and the ClinicVisit table is therefore 1:M because the patient can go for many clinic visits. Each clinic visit shares a 1:1 relationship to the AppointmentReport, AdherenceReport etc tables because one clinic visit outputs only one of each type of reports.

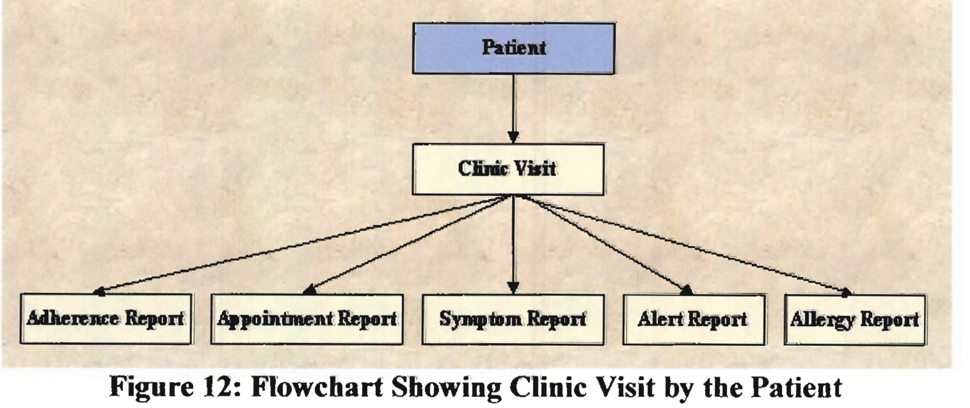

Figure 12: Flowchart Showing Clinic Visit by the Patient

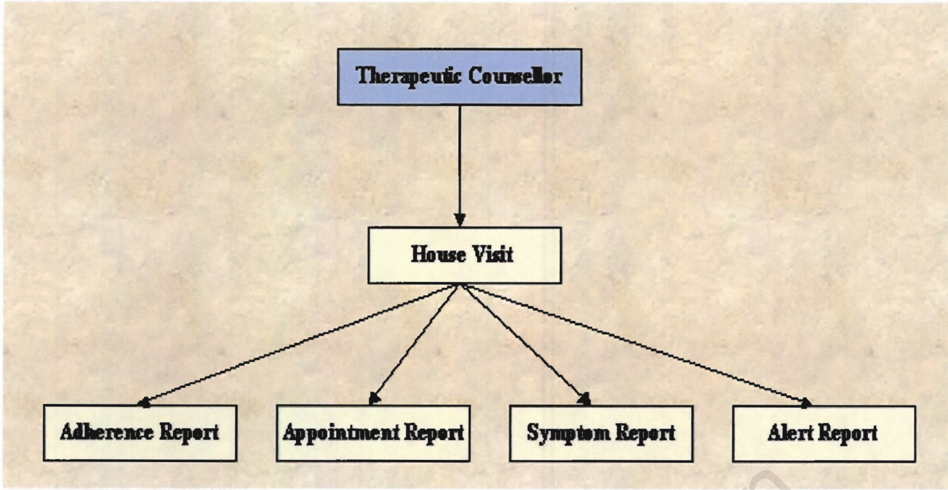

Figure 13: Flowchart Showing House Visit by the Therapeutic Counsellor

As mentioned in section 4.2.2, a therapeutic counsellor collects data during a house visit. Figure 13 shows that the relationship between the therapeutic counsellor and the House Visit table is 1:M because the therapeutic counsellor can go for many house visits. The HouseVisit table shares a 1:1 relationship to the AppointmentReport, AdherenceReport etc tables. House visit does not update Allergy report because only physicians can diagnose allergy reactions. The ViralLoad, StageOfHIV and CD4Count tables are also updated after a clinic visit. It was decided to have them as separate and standalone tables rather than include their respective attributes in the ClinicVisit table because these tables are only updated every 4-6 weeks and not at each clinic visit. Figure 14 shows the entity relationship diagram of the database. The relationship between the Physician table and the ClinicVisit is 1:M because one physician can go for many clinic visits. The Patient table was split into five tables namely PatientMiscellaneousInfo, PatientClinicalInfo, PatientFinancialInfo, PatientMedicalHistory and the relationship between these tables is 1:1.

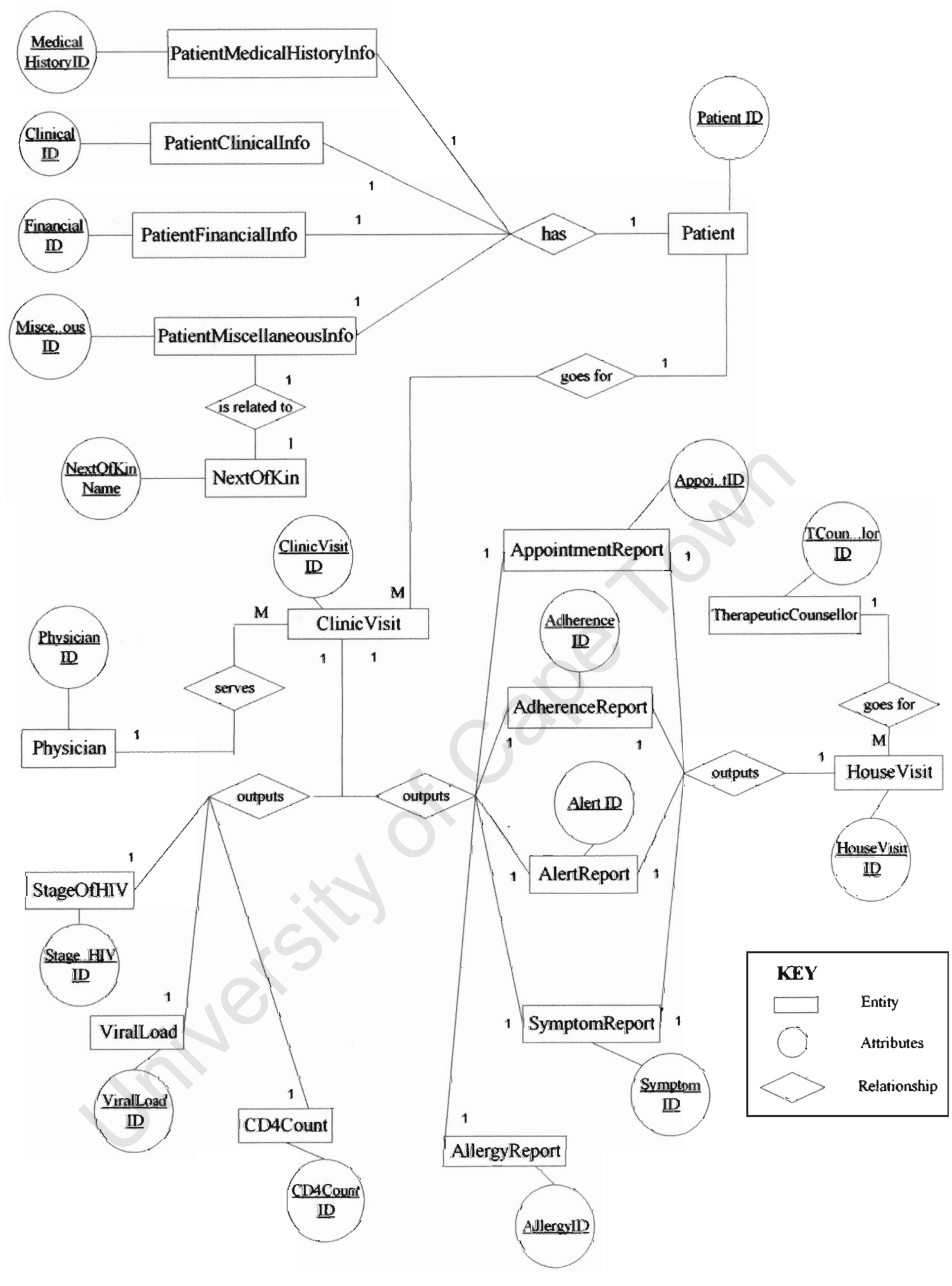

Figure 14: E-R Diagram of the HIV/AIDS Database

4.2.4 Physical Modelling

Physical modelling is the translation of the logical description of data into the technical specifications for storing and retrieving data. In essence, the goal is to create a design for storing data that will provide adequate performance and insure database integrity, security and recoverability. Physical modelling is highly dependent on the DBMS, that is the software, and also on the capacity of the hardware system. During this phase, the various options available in the DBMS in terms of file organisation and access requirements are considered.

4.3 Data Acquisition and Populating the Database

Since the design of the database was based on the Gugulethu pilot study, data collected by the clinic was used to populate the database. Due to missing data in the paper records, acquiring data for each field in the database tables was not possible. Appendix B shows the HIV/AIDS data acquired from the data manager based at the Somerset West Hospital in Cape Town. Since the data obtained included only PatientNumber, CD4Count, ViralLoad, Gender, Age and StageOfHIV, the database was populated with realistic data for the purpose of completeness and testing.

4.4 Data Confidentiality and Access

A high level of sensitivity is attached to HIV/AIDS related information and the way in which the information is handled. HIV/AIDS carries a stigma that seriously affects people with HIV/AIDS and those close to them. Public fear about the pandemic still exists and such fear can result in social discrimination, isolation and unjustified persecution. People with HIV experience feelings of shame because of other people's attitudes towards them and this makes living with HIV even more difficult and challenging. Therefore, confidentiality is essential and as protection of privacy is an important issue, HIV/AIDS related information may not be given to unauthorized people. Policies need to be established about who has access to what information. In the database design context, access refers to the right to create, read, append, revise or delete information. Once an access policy is established, the world is divided into two distinct sets of people: those who have the right and those who do not. Appropriate measures such as encryption and issuing password to the future users of the HIV/AIDS database will restrict access to patient records. It is important to respect the rights and needs of people living with HIV/AIDS and to ensure that they are protected from intrusion into their personal lives.

4.5 The Proposed HIV/AIDS Database

The purpose of the HIV/AIDS database is to establish whether it can facilitate the management of HIV/AIDS patient data at the Gugulethu community clinic. Since the project is being investigated on a small scale, Microsoft® Access was the chosen software for the design of the HIV/AIDS database as it is widely distributed and economically viable. MS Access allows users to quickly and easily analyses information and offers an easy-to-use database for managing and sharing data. The information within the database can be viewed, sorted, manipulated, retrieved and printed in various ways and gives users the flexibility to obtain data in multiple formats.

Figure 15 below is an output of the design of the HIV/AIDS database showing the relationships between the different entities and their attributes.

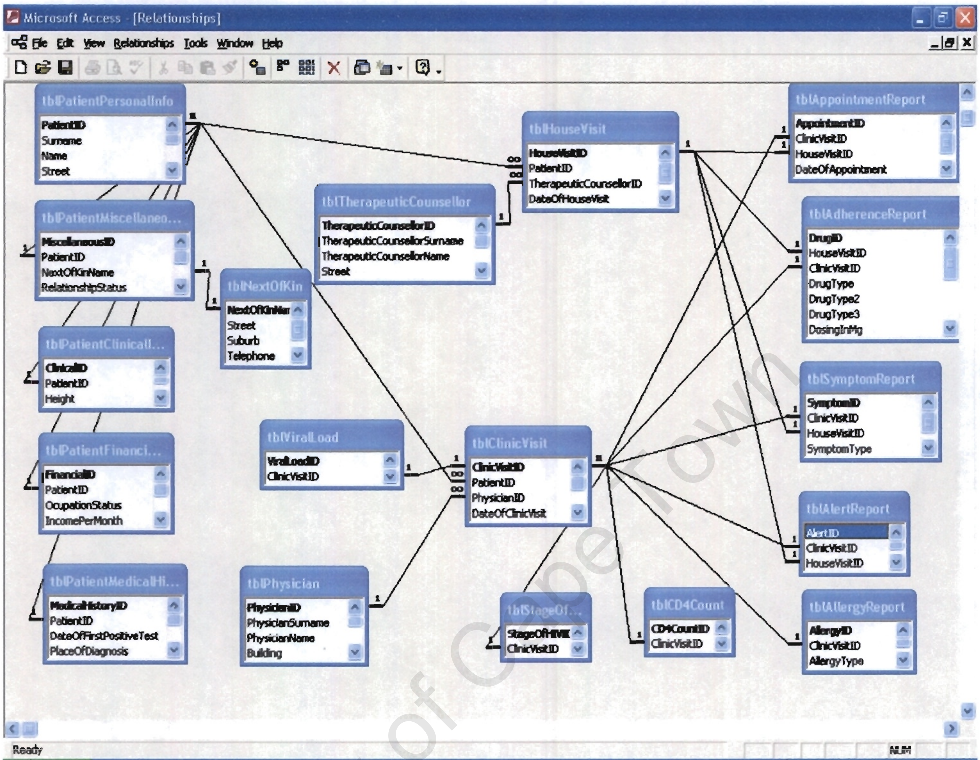

Figure 15: Design of the HIV/AIDS Database

As stated by Longley et al. [1999], not all users see the world through the same eyes and for the system to be effective, it must have the confidence of all the users. Since most of the users will not be concerned with how the database works, the system should be designed such that it meets the interests, skills and needs of the individual user. In view of increasing the potential benefits of the system, well-designed and user-friendly interfaces are developed to reduce the need to memorise commands and to provide visual feedback.

Figure 16 shows the user display of the HIV/AIDS database system. Chapter Six describes the evaluation phase and discussion of the database, which reflects the confidence of the prospective users. Appendix C shows the different user interfaces within the HIV/AIDS database. The CD available in Appendix D contains a digital copy of the HIV/AIDS database.

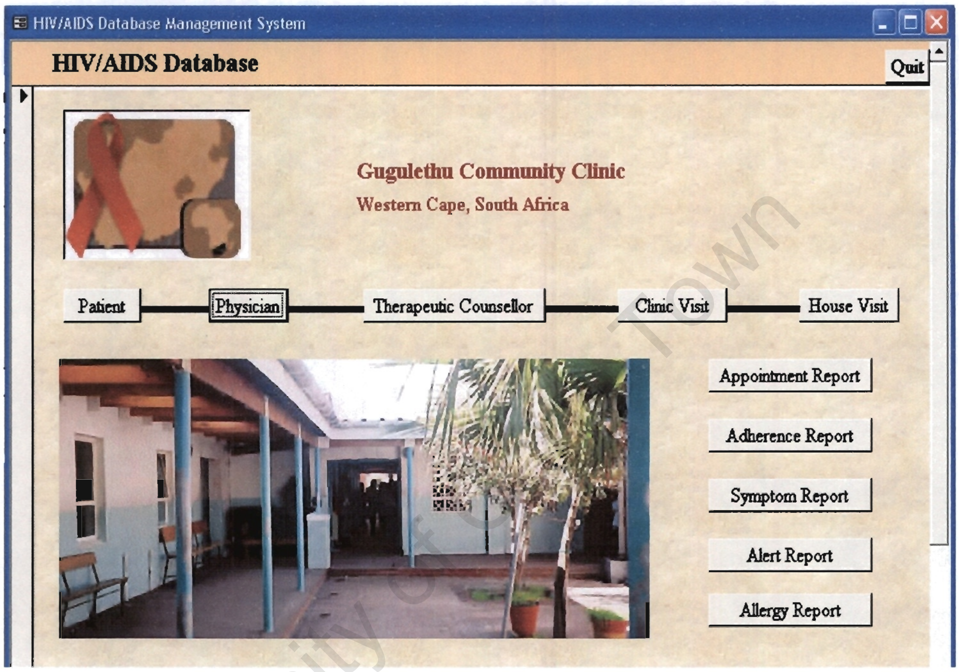

Figure 16: User Display of the HIV/AIDS Database

The various menus in the HIV/AIDS database record information concerning the patient's health, the medication, the adherence patterns as well as possible need for appointments, what allergies and symptoms they are experiencing and how severe these are. The design of data input screens as shown in Figure 17 standardises data collection and ensures accurate data entry.

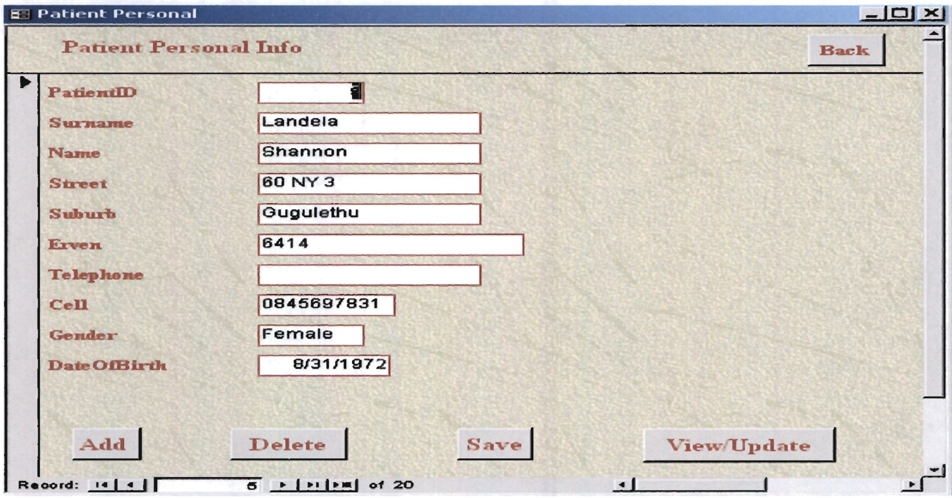

Figure 17: Data Input Screen of the HIV/AIDS Database

Other functions within the HIV/AIDS database allow users to find and update the records as shown in Figure 18. This interface allows the user to select the particular field he/she wants to view or update from a drop down menu.

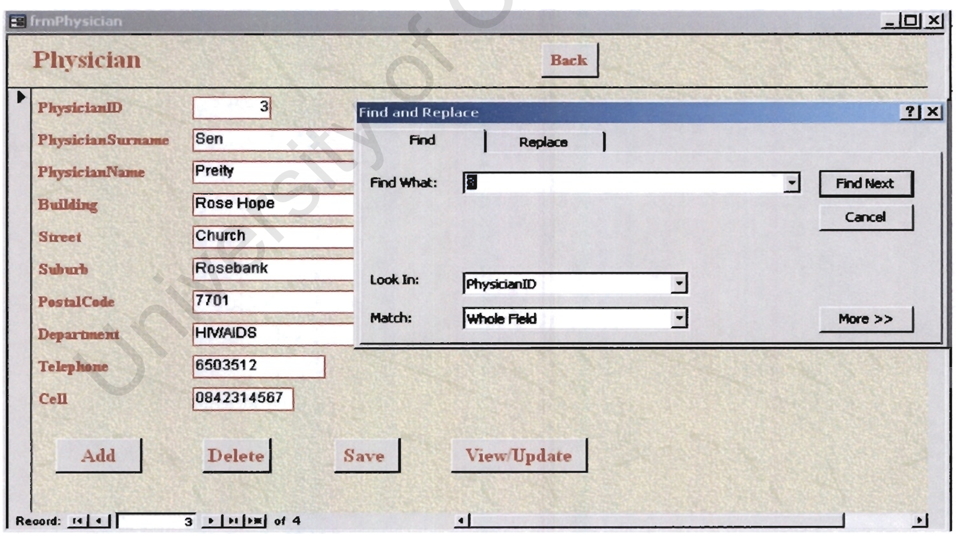

Figure 18: Finding and Updating the Records

Microsoft® Access also allows automated query and report procedures as shown in Figure 19 and Figure 20 respectively. Figure 19 shows the query between two tables namely: HouseVisit and AdherenceReport. The output shows the dates of house visits and the different medications that the patients are taking.

qryAdherenceReport2 : Select Query

HouseVisitID	PatientID	DateOfHouseVisit	DrugID	DrugType	DrugType2	DrugType3	Dosin
1	1	3/15/2003	21	[illegible]	Nelfinavir	Ritonavir	
2	2	3/15/2003	22	Zidovudine	Didanosine	Nevirapine	
3	3	3/15/2003	23	Zidovudine	Didanosine	Nevirapine	
4	4	3/15/2003	24	AZT	3TC	Ritonavir	
5	5	3/15/2003	25	Efavirene	Nelfinavir	Nevirapine	
6	6	4/16/2003	26	Efavirene	Nelfinavir	Nevirapine	
7	7	4/16/2003	27	Efavirene	Nelfinavir	Nevirapine	
8	8	4/16/2003	28	Zidovudine	Didanosine	dd1	
9	9	4/16/2003	29	Zidovudine	Didanosine	Ritonavir	
10	10	4/16/2003	30	Zidovudine	Didanosine	Ritonavir	
11	11	5/18/2003	31	Zidovudine	Didanosine	Ritonavir	
12	12	5/18/2003	32	Zidovudine	Didanosine	Nevirapine	
13	13	5/18/2003	33	Zidovudine	Didanosine	Nevirapine	

Record: 1 of 20

Figure 19: Querying the HIV/AIDS Database

Adherence Report

ClinicVisitID	1
PatientID	1
DateOfClinicVisit	2/1/2003
DrugID	1
DrugType	Efavirene
DrugType2	Nelfinavir
DrugType3	Ritonavir
DosingInMg	12
DosingTimes	3
DrugSideEffect	
SideEffectStarted	
SideEffectEnded	
PillCount	20
OneDayAgo	3
TwoDaysAgo	2
ThreeDaysAgo	2
ReportTime	9:00:00 AM
Diagnosis	Stable
PatientWeight	55

Figure 20: Report Creation

The results of queries and reports help the users to focus, examine and abstract the resources rather than understand the intricacies of the individual tables. The aim is to make it easy for the users to find out the type of data, which exist and provide the tools for appropriate information editing and retrieval that will help them with the maintenance of the patient-medication related documentation.

4.5.1 Future Scope of the HIV/AIDS Database

Any new database is viewed as unfinished work. The complete medical records of patients within the HIV/AIDS database are very valuable information. The database can be further extended to improve the supply chain management of antiretroviral drugs. Less time would then be spent on inventory management since whenever the stock is low, new orders can be placed.

The development of an HIV/AIDS database is a positive opportunity that can be of immense practical value to health professionals. The author believes that the HIV/AIDS database represents a significant step forward and with the application of SIS, the system will help to the various needs of physicians, health managers and health officials in terms of decision-making processes.

This chapter addressed the objectives of the study by discussing the design of an HIV/AIDS database in the context of maintaining, managing and monitoring patients-medication related information. The concepts of data acquisition, access and confidentiality are also featured. This chapter leads to the proposed design of the SIMS and will describe how patient-related information is translated into the system.

5.0 THE PROPOSED SPATIAL INFORMATION MANAGEMENT SYSTEM

5.1 Introduction

This chapter introduces the proposed Spatial Information Management System. Firstly, the different stages involved in the development of the SIMS are explained. The chapter continues by featuring the paradigm for the SIMS. The last section focuses on the different functionalities delivered by the system.

5.2 The SIMS Development

The aim is to design and develop a system, which will help the future users namely: physicians, health managers and decision-makers, to plan and analyse health outcomes. The system is developed such that it adds value to the health sector in terms of streamlining the decision-making process concerning health policies and enhancing health services' capability.

The different phases involved in the development of the SIMS are:

- The choice of an appropriate software package that will support spatial data formats.
- Conceptual design of the SIMS.
- Building the geodatabase.
- The geocoding process.

5.2.1 Choice of Software and Spatial Data for the design of the SIMS

The ESRI family of software that was chosen to design the SIMS is known as ArcGIS 8.2. ArcGIS is a scalable system for geographic data creation, management, integration and analysis. As SIS expands into new applications and user communities, ArcGIS meets the challenge of providing the data and services to a geographically literate world. Strong editing, analysis and management distinguish ArcGIS as the leading SIS software. ArcGIS 8.2 applications include ArcMap™, ArcCatalog™ and ArcToolbox™ support. Developing the SIMS involves using ArcMap for creating cartographic output and ArcCatalog for locating and managing data.

After careful thought and considerations, the spatial data to be included in the SIMS was chosen. As explained in Chapter One Section 1.1, adequate physical infrastructure is complementary to the efficient management of HIV/AIDS and the location of patients in perspective of existing infrastructure will provide a clear outlook, insight and vision to health officials and decision-makers. Hence, the SIMS is conceptualised as a series of layers of information including:

- The health districts
- The erven
- The location of health centres: clinics, government hospitals and private hospitals
- The location of roads and streets
- The location of main transport routes: taxi and bus
- The basic amenities: water, telephone, sanitation and fuel for lighting.

The data in shapefile format was obtained from the Cape Metropolitan Council (CMC) of Cape Town. The spatial references of the data are as follows: coordinate system is Lo 19, projection name is Transverse Mercator and the datum is World Geodetic System 84 (WGS 84).

5.2.2 The Conceptual Design of the SIMS

Figure 21 shows the conceptual design of the SIMS whereby the spatial data and the non-spatial data are integrated in the SIMS geodatabase in ArcGIS. The software allows for inputting, updating and analysing the data while maintaining the spatial integrity of each data collection. The technology also supports the spatial display of data, map layouts and handles queries and reports.

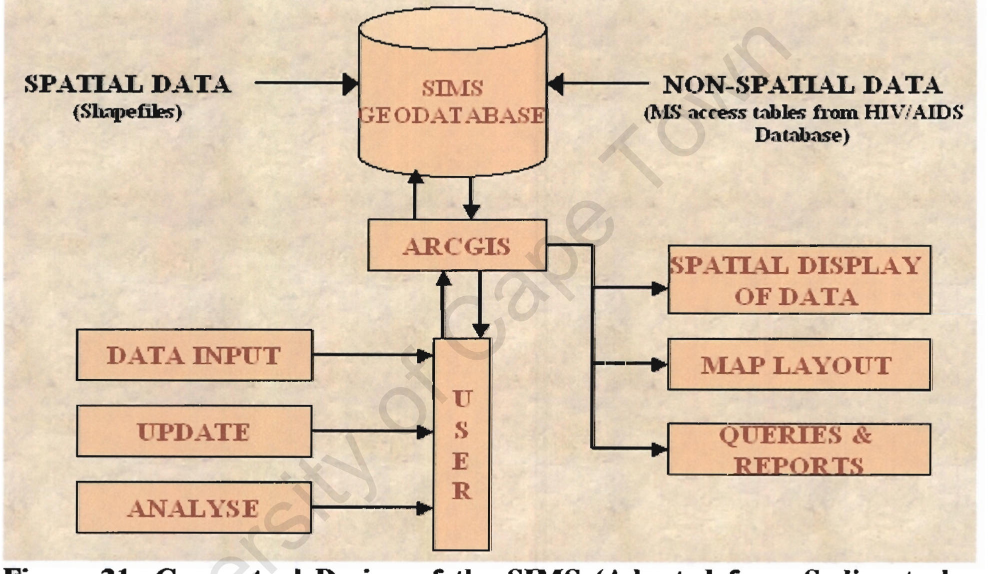

Figure 21: Conceptual Design of the SIMS (Adapted from Sadiq et al. undated)

5.2.3 Building the Geodatabase

With the spatial data existing as shapefiles and the non-spatial data residing in the HIV/AIDS database, the next stage in the design of the SIMS was to build a geodatabase. A geodatabase is a physical store of geographic information inside a DBMS. Figure 22 below shows the creation of a personal geodatabase using the ArcCatalog application.

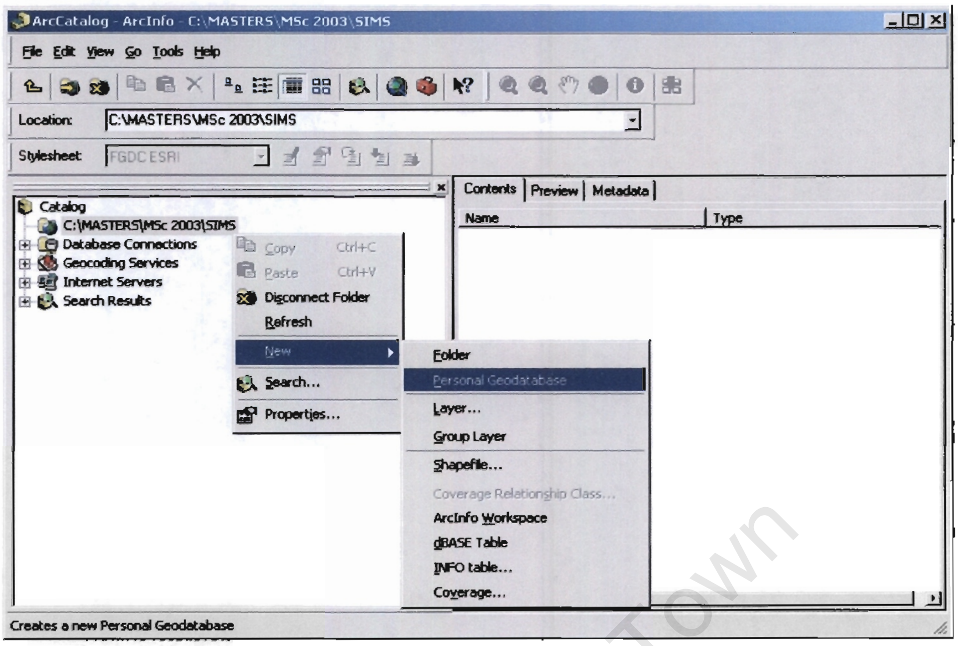

Figure 22: Creating a New Personal Geodatabase

Loading the spatial data into the geodatabase involved importing the shapefiles as shown in Figure 23. Figure 24 displays the creation of new tables and the importing and loading of non-spatial data from the HIV/AIDS database into the personal geodatabase.

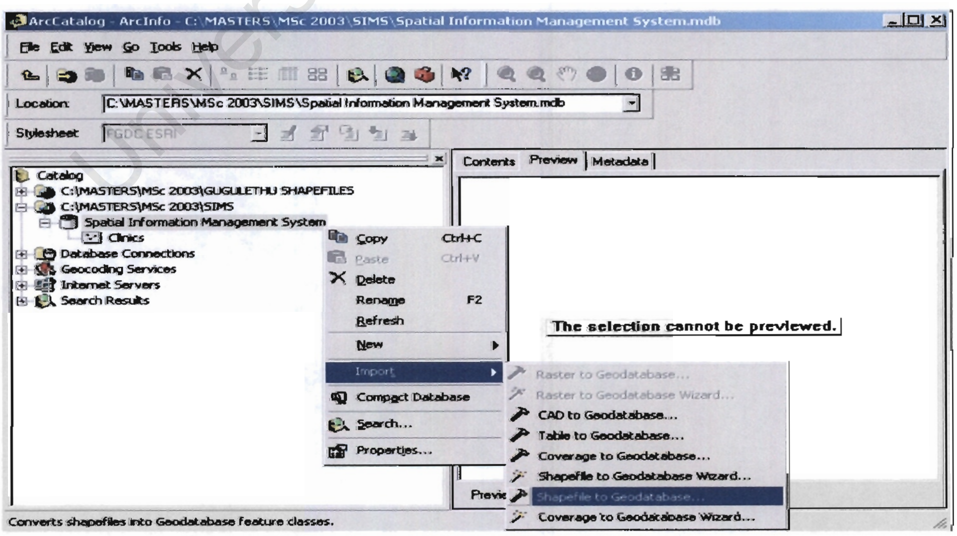

Figure 23: Importing Shapefile to Geodatabase

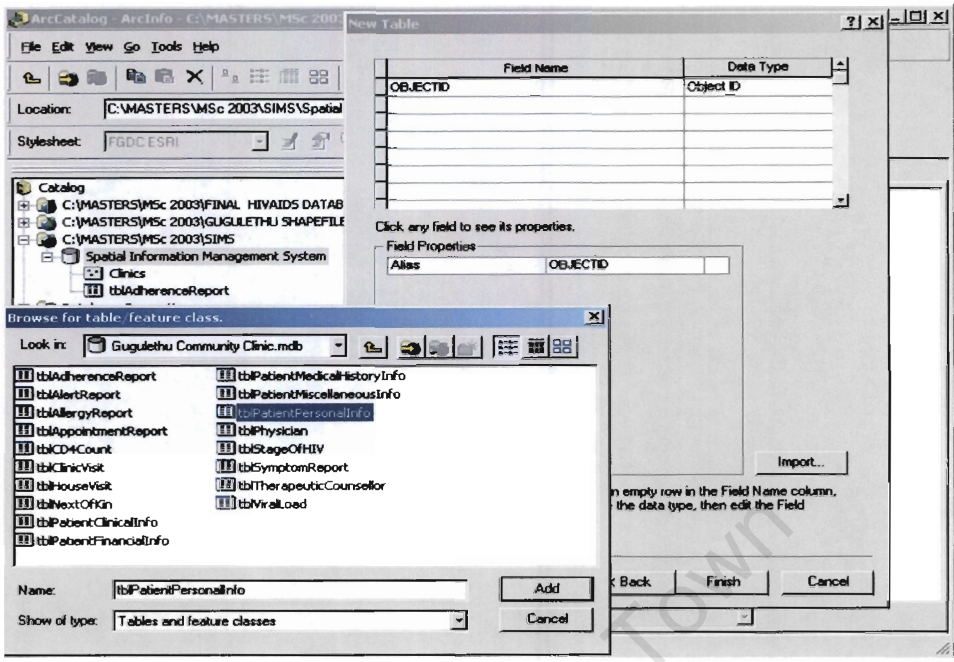

Figure 24: Creating a New Table and Importing Non-Spatial Data

5.2.4 The Geocoding Process

The geocoding functionality within ArcGIS supports and facilitates the integration of data records by location. This functionality means that patient-related data can be geographically located. Geocoding is a comparison of each address in an event table with the address in a target address database. For the purpose of the study, the street address in the PatientPersonalInfo and the TherapeuticCounsellor tables have to match the street address in the Erven table. An extra field called 'STREET' was added to the Erven table and corresponding street addresses were edited using the ArcMap application as shown in Figure 25.

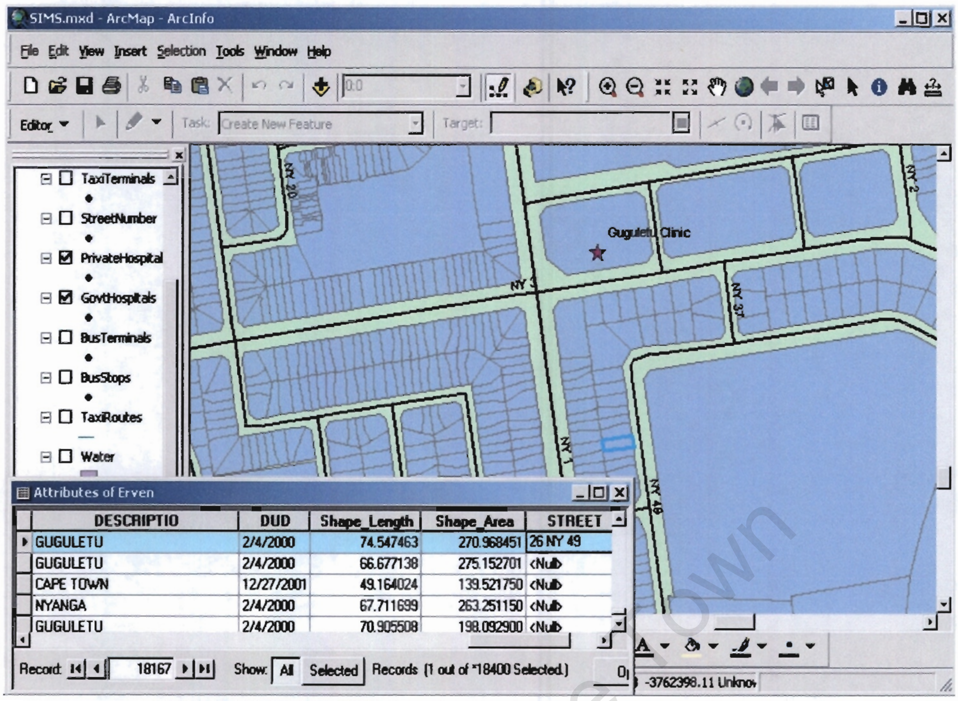

Figure 25: Editing the Erven table with Corresponding Street Addresses

The creation of a new geocoding service was done via the ArcCatalog interface as shown in Figure 25 and the geocoding wizard within ArcMap supported the geographical location of the HIV patients and the therapeutic counsellors as displayed in Figure 26.

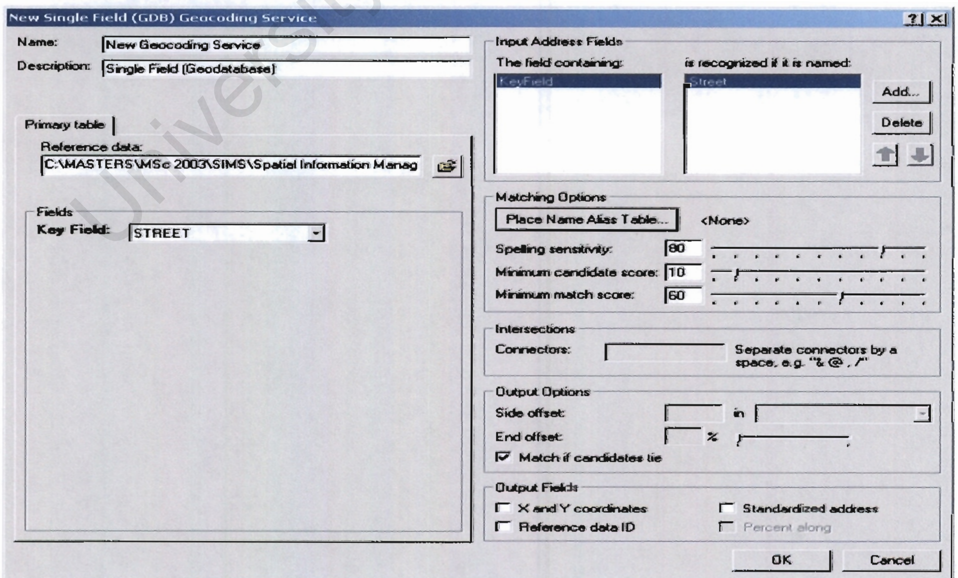

Figure 26: Creating a New Geocoding Service

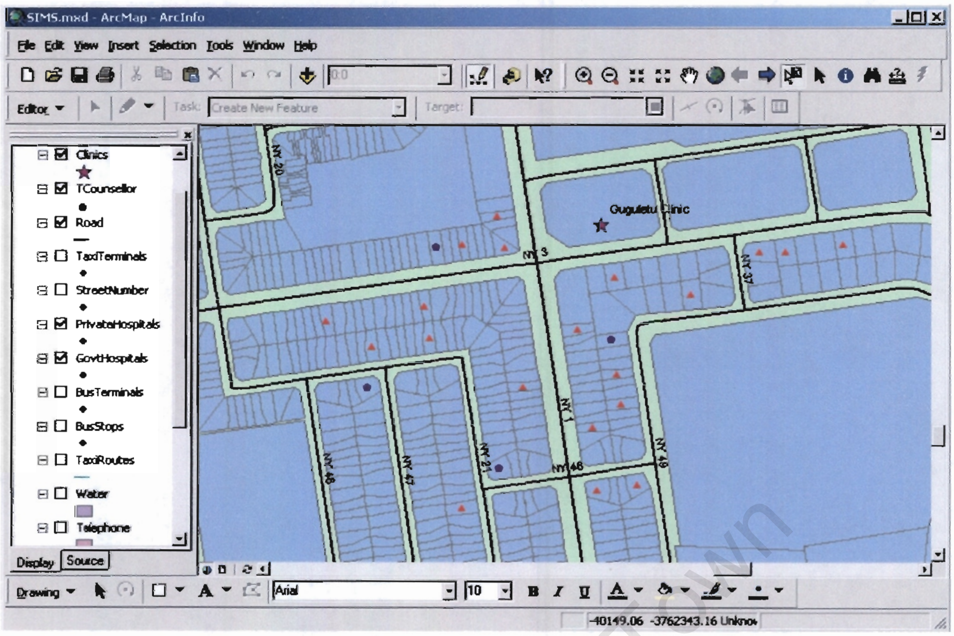

Figure 27: Location of the HIV patients and the Therapeutic Counsellors

The overlay of the quantitative graphics provides the ability to realize the spatial distribution of the HIV patients in the Gugulethu region in a clear manner. The display depicts ground reality: the red triangles represent the location of the HIV patients while the purple pentagons locate the therapeutic counsellors. The strong point of the system is the ability to identify and access information about any particular patient on the map as shown in Figure 28.

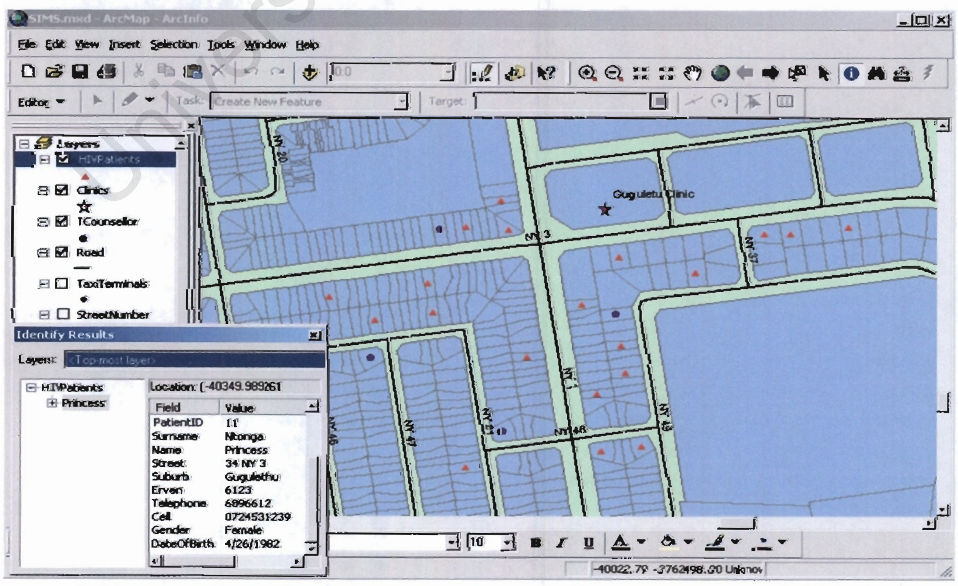

Figure 28: Identifying Patients on the map

5.3 The Spatial Information Management System (SIMS)

The simplified paradigm for the SIMS as shown in Figure 29 below can be viewed in three phases: data source identification, SIS support system and health management. The SIMS's ability to collate, integrate and display population-based data and infrastructure data warrants a broader, more holistic perspective on the health of the populations.

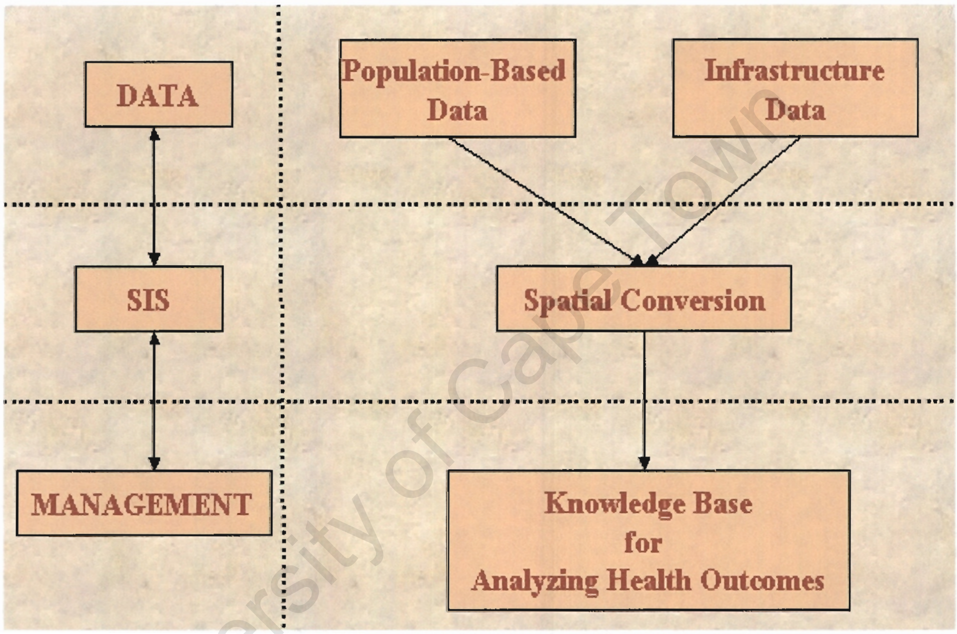

Figure 29: Paradigm for the SIMS (Adapted from Liao et al. 1998)

The SIMS (see Appendix D) delivers the complete requirements for a data-driven information system, which features the following functionalities:

- The visualisation of the HIV/AIDS distribution. The spatial distribution provides a clear representation of HIV/AIDS people. The areas, which are more prone to the pandemic, are thus identified. The 'hot spots' are earmarked and health professionals can initiate strategies as to how to curb the further spread of the disease.

- The display of the existing infrastructure as shown in Figure 30 below provides an insight into the lifestyles of the HIV infected patients in terms of availability of basic amenities and means of transport.

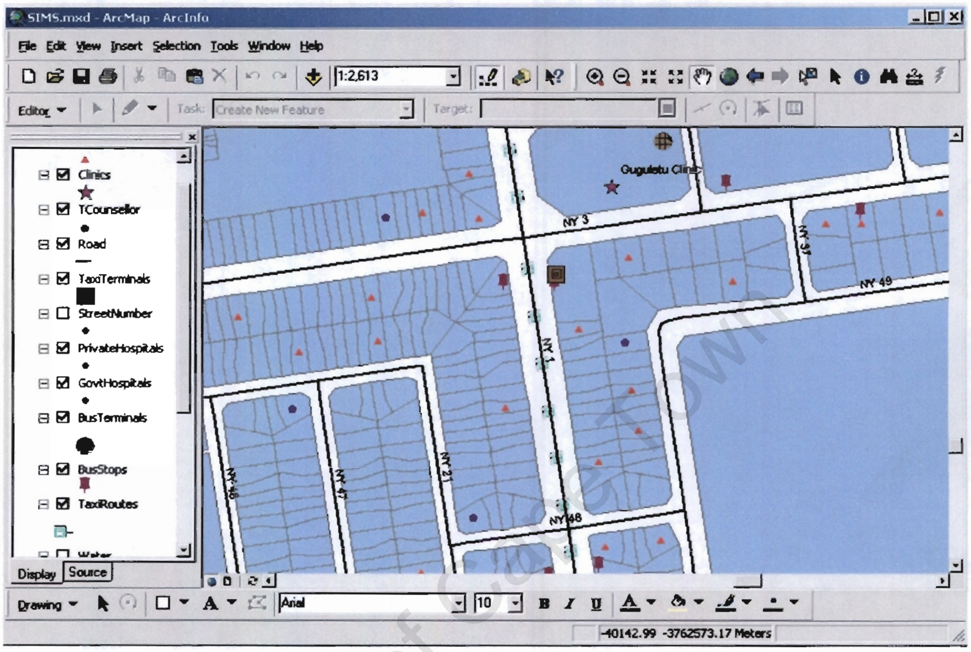

Figure 30: Display of Existing Infrastructure

- Comparisons and relationships relating to the spatial distribution of HIV/AIDS patients can be drawn between areas with infrastructure and other areas with non-adequate infrastructure as shown in Figure 31. The green region shows areas with infrastructure while the blue region shows areas with non-adequate infrastructure. In addition, decisions can be made concerning the allocation of resources in underprivileged regions.

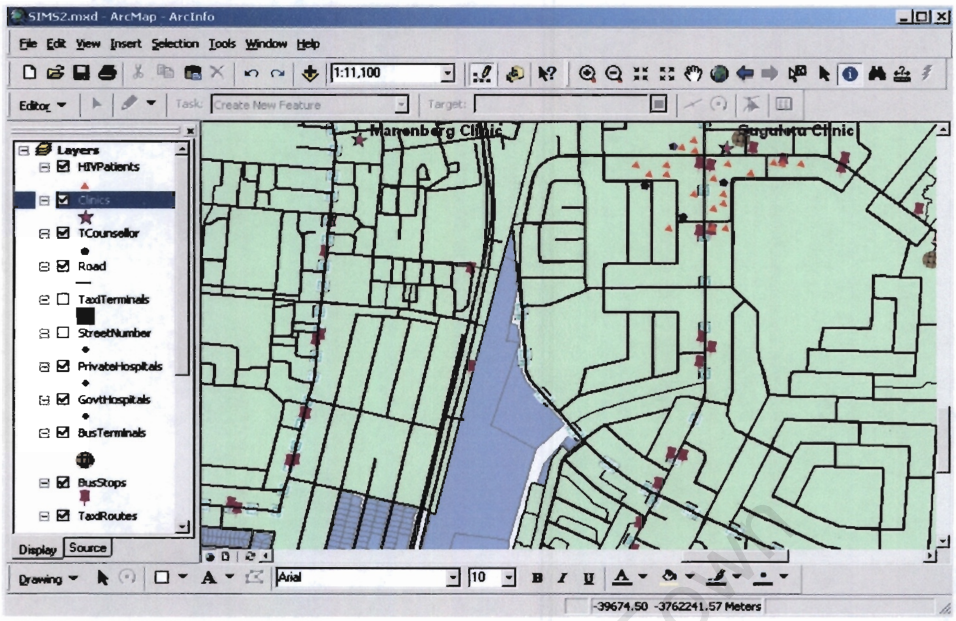

Figure 31: Areas with Infrastructure and Areas with Non-adequate Infrastructure

- The spatial distribution of the population in relation to health centre positions assesses the accessibility to appropriate health services. Health officials can utilise this information to site additional health centres with the aim of minimising the distances that patients need to travel to obtain care and services.

- The distance that the therapeutic counsellors need to travel for their regular house visits can also be calculated as shown in Figure 32 below. This information is useful in coordinating the roles and responsibilities of the therapeutic counsellors so that they counsel patients living in the same vicinity rather than miles away.

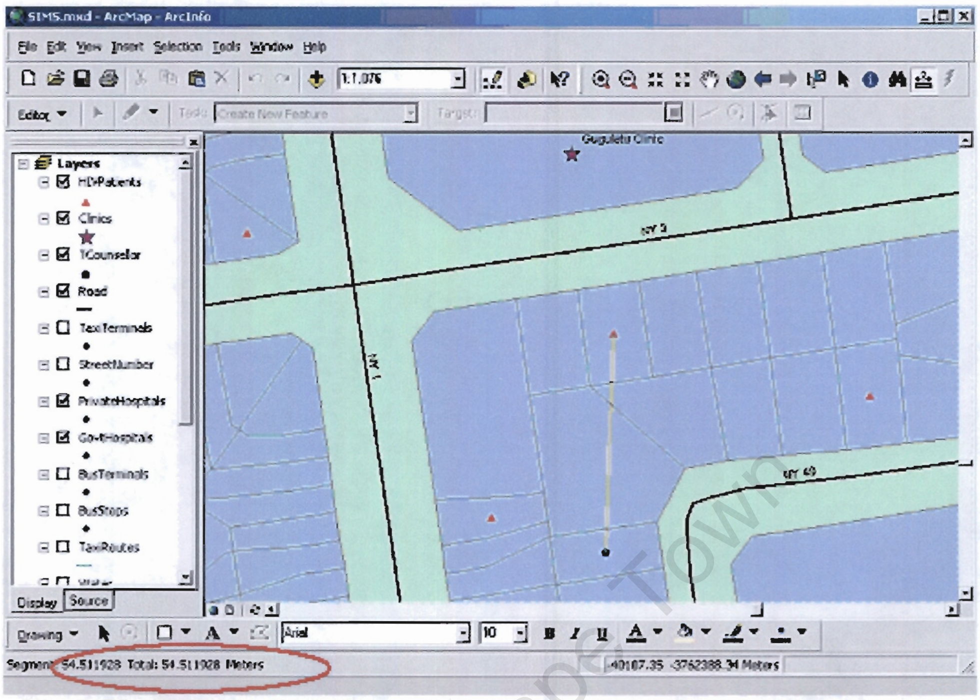

Figure 32: Distance Calculation between Therapeutic Counsellor's House and Patient's House

- It is a powerful management and decision-making support system that enables decision-makers to identify and prioritise population health needs, configure health care delivery systems, evaluate and service utilization and health outcomes.

- Last but not least, SIMS can be regarded as a virtual information bank that allow focused, long-term and cost effective HIV/AIDS management thus contributing to health development.

This chapter has reviewed the design and development of the proposed SIMS, which could be utilised by health managers and decision-makers to efficiently manage HIV/AIDS in South Africa. The different stages involved in the development of the system have been thoroughly described. The paradigm for the SIMS is also included. The last section of the chapter, which emphasises the different functionalities of the SIMS, shows how the system can help in providing better health services and delivery, thus contributing to health development. The next chapter evaluates the proposed HIV/AIDS database and the proposed SIMS.

6.0 EVALUATION OF THE SIMS

6.1 Introduction

Objectives (3) of this thesis aims to evaluate the SIMS. The evaluation of the SIMS was carried out during the last phase of the dissertation. The evaluation involved a presentation to the prospective users namely: the physicians, the health managers, the data managers, the administrative clerks and the registered nurses. The purpose of the evaluation process was to obtain qualitative feedback and responses from the prospective users on the SIMS. Figure 33 below shows the types of access for the different users. However, the implementation process of the system would involve a more detailed user needs assessment and characteristics.

Users	HIV/AIDS Database			SIMS		
	Edit	View	Print	Edit	View	Print
Physicians	Yes	Yes	Yes	Yes	Yes	Yes
Administrative Clerks	Yes	Yes	Yes	No	No	No
Registered Nurses	Yes	Yes	Yes	No	No	No
Data Managers	Yes	Yes	Yes	Yes	Yes	Yes
Health Managers	Yes	Yes	Yes	Yes	Yes	Yes

Figure 33: Types of Access for the Different Users

6.2 Evaluation of the SIMS

The users recognized the need for the HIV/AIDS database and were able to visualise the value of the SIMS. The feedback and responses from the prospective users were positive and they showed much interest during the evaluation phase.

The users had some suggestions regarding the database which were noted as follows: the blood group field in the table PatientClinicalInfo should be removed for such type of information is only required in case of surgery and the stage of HIV data should be collected as stage 1, 2, 3, and 4 instead of very early, early, late and final.

The customised interfaces proved to be simple and easily understood and used among the users. The visualisation of the HIV/AIDS patients and the therapeutic counsellors with respect to the location of the health centres provided a clear representation of the HIV/AIDS distribution and was much appreciated. Positive feedback was received from users upon hearing that SIMS could also assess the accessibility to health centres, as this was a task that they have been doing manually.

The main concerns of the users were:

- The transition from paper-based management system to a computerised management system would be difficult.
- The issue of confidentiality must be addressed.

The users believed that if the system were to be implemented throughout South Africa, the most difficult phase would be the transition from the paper-based system to the computerised one. They further stated that physicians are used to paperwork and working on computers is regarded as challenging if not scary.

The physicians and health managers would have to be persuaded and the mindset of some of them would have to be changed to make them realise the potential value of the management system. They must see the usefulness of the system and realise it as a tool to manage and optimise their entire workflow. Physicians already have hectic schedules and learning new software to accomplish their medical tasks might not be very welcoming. However, one of the physicians argued that implementing the database at the Gugulethu community clinic would be quite smooth due to the fact that paper-based records already exist [Orrell 2003]. This means that should any training sessions be required, the staffs will be competent to cope with the training. On the other hand, underprivileged health centres in rural South Africa barely have the adequate medical infrastructure let alone the necessary physical infrastructure. Therefore, setting up such a system would be both challenging and complex.

The issue of confidentiality is yet another concern of the users. HIV/AIDS patients reveal highly sensitive information to physicians and if health professionals misuse or misrecord the confidential information, it might be difficult to correct them or hold anyone accountable. The users felt that access to the system would need to be restricted in order for privacy to be protected. The system must ensure that information is used appropriately or people will avoid using it.

The confidential information should be shared only among authorized people and some balance must be struck between an individual's right to keep information confidential and the benefits that can be accrued if the information is made public. In addition, the records must have adequate security in terms of encryption measures such that personal information about patients is not divulged broadly. Another concern expressed by the users is that even if the patients' names are removed from their records, their identities can be determined by correlating the data with their addresses.

Still, while the confidentiality of paper-based records is easily compromised by authorized people who misuse their access to patient information, the sheer bulk of paper records helps to keep them private. It was suggested that physicians should inform their fellow patients why their information is being collected, how it will be protected, and how it will be used.

Ultimately, the users positively affirmed the benefit of using the SIMS as a valuable tool to properly administer and retrieve the patient-medication related data, locate the HIV/AIDS people and the existing infrastructure in view of providing a spur to improve health care service and delivery.

This chapter has discussed the feedback and responses of the prospective users on the SIMS. Some changes to the fields within the database tables were suggested. Concerns of the users with respect to the SIMS were also brought forward. Finally, the users established that the SIMS could be used as an information management tool for the management of HIV/AIDS.

7.0 SUMMARY AND CONCLUSIONS

This study focused on the design and development of an HIV/AIDS database and an SIMS, which could be used as an information gathering and management tool in South Africa for the management of HIV/AIDS. As the necessary physical infrastructure is not yet in place for an effective management of HIV/AIDS in South Africa, the research was motivated by the need to provide a "virtual" infrastructure of support. In essence, the development of the SIMS is to properly administer and retrieve the patient-medication related data, locate the HIV/AIDS patients and the existing infrastructure, contribute to decision-making and policy development in view of providing a spur to improve health care service and delivery.

The review of literature on the treatment of Tuberculosis and the control of Malaria has acknowledged the relevance of SIS in the health management framework. It has shown that SIS holds promise for the management of HIV/AIDS. The author has drawn on some of the findings and experiences reported in the literature, in order to design and develop an HIV/AIDS database and SIMS to address the issues of data distribution and management.

The Gugulethu community in the Nyanga district in the Western Cape province in South Africa has served as a pilot project to establish parameters and benchmarks that could be used in other communities. The standard of living of the residents and the different existing infrastructure in the community were described and the impact of the HIV/AIDS pandemic on the people was featured. The challenges that the staffs at the clinic were facing with the paper-based management system have been thoroughly described.

The need for a database system in the Gugulethu community clinic has also been addressed for it could serve as an effective tool to support data collection, recording and updating. By keeping all the patient-medication records digitally, information retrieval will no longer be a tedious task of looking through volumes of paper records.

Addressing the first objective of the study, the design and development of an HIV/AIDS database was proposed which offered a solution to the Gugulethu HIV/AIDS clinic to record, maintain and administer information about HIV infected patients. The needs and expectations of the prospective users have been addressed and the data requirements for the development of the database have been analysed. The concepts of data acquisition, access and confidentiality have also been featured. The database has represented a significant step forward and with the application of SIS, the system could help to address the various needs of physicians, health managers and health officials in terms of decision-making and policy-making.

The second objective of the thesis entailed the design and development of a SIMS. The different stages involved in the development of the SIMS encapsulate the translation of patient-related information into the system and the spatial distribution of the HIV/AIDS patients. The SIMS's ability to collate, integrate and display population-based data and infrastructure data warranted a broader, more holistic perspective on the health of the population. The SIMS has delivered the complete requirements for a data-driven information system and has featured numerous functionalities. It could be regarded as a virtual information bank that allows focused, long-term and cost effective HIV/AIDS management thus contributing to health development.

The last objective of the dissertation was to evaluate the SIMS. The evaluation of the SIMS was carried out during the last phase of the thesis and involved doing a presentation to the prospective users. The feedback and responses of the prospective users on the SIMS have been discussed. The two main concerns of the users included the transition from paper-based management system to a computerised management system and the issue of confidentiality. These concerns have been documented.

Based on the findings of this study, it can be noted that implementing the SIMS to manage HIV/AIDS across South Africa is a long-term undertaking. SIMS cannot miraculously solve the HIV/AIDS pandemic across South Africa but is seen as an innovative information-gathering tool that can be employed in the mobilization and response to the disease. The SIMS can perform several functions, fulfill many roles and may provide tremendous opportunities in HIV/AIDS patients' health informatics in South Africa. The functions of the information management tool would be to properly administer and retrieve the patient-medication related data, locate the HIV/AIDS patients and the existing infrastructure in view of providing a spur to improve health care service and delivery. The technology is regarded as a vehicle for facilitating public health planning and contributing to community-based decision-making and policy development.

8.0 RECOMMENDATIONS

This study has addressed a SIMS, which could offer a "virtual" infrastructure of support for the management of HIV/AIDS in South Africa. The design and development aspects of the information management tool have been discussed but there are certain areas that could be investigated and developed further.

Firstly, complete medical records of patients are very valuable information and can open new dimensions of research. Instead of the HIV/AIDS database standing alone, other databases such as Tuberculosis, Malaria etc can be integrated into the SIMS. In this regard, the HIV/AIDS, Tuberculosis and Malaria patients can all be mapped spatially, enabling physicians and health officials to visualise the three different patterns and to draw comparisons among the three most important diseases in South Africa. The overlay of the HIV/AIDS, Tuberculosis and Malaria distribution can also identify critical "hot spots" where additional support is needed. The three databases residing in the SIMS can provide a powerful management and decision-making support system that enables decision-makers to identify population health needs and prioritise these needs, configure health care delivery systems, evaluate and service utilization and health outcomes. In addition, collaborative projects and data access, distribution and sharing among the country's health centres can ensure a continuous and current understanding of the diseases profile in South Africa.

The SIMS can also be extended to manage inventories in other areas of a health centre. It can be linked to a pharmaceutical information system for dispensary medication and drug supply management. By providing an instant and much needed communication link between physicians and pharmacists, less time can be spent on inventory management since whenever the stock is low, new orders can be placed. The combination of a laboratory information system to the SIMS is also possible thus supporting the issuing of laboratory reports such as blood group tests. The ability to link different datasets can further help in the planning of cost-effective interventions.

Lastly, the author recommends that the implementation plan of the proposed SIMS should initially involve a needs assessment study (See Nxumalo 2003). In addition, since confidentiality, protection of privacy and high level of sensitivity are attached to HIV/AIDS related information, database programmers should be hired to deal with the access policy and encryption issues.

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Personal Communication:

Bekker LG, 2002/2003: Department of Medecine, UCT Medical School
Benvie E, 2002: Project Manager, Deloitte & Touche Corporate AIDS Survey
De Kock S, 2003: Data Manager, Somerset Hospital
Greene D, 2002: Chapel Street Clinic, Woodstock
Kramer S, 2002: Head, AIDS Research Unit, Metropolitan Group
Orrell C, 2002/2003: HIV Research Unit, The University of Cape Town

Panter C, 2002: Coordinator, DaimlerChrysler South Africa HIV/AIDS Programme
Regensberg L, 2002: Senior Medical Advisor, Medscheme's Integrated Care Division
Reuter H, 2002: Medecins sans Frontieres primary care based ARV programme in Khayelitsha
Magwa J, 2003: Registered Nurse, Gugulethu community clinic
Marks AS, 2002: Senior Lecturer, GSB; UCT HIV/AIDS Working Group
Matoti K, 2003: Physician, Gugulethu community clinic

APPENDIX A: PAPER-BASED COLLECTION OF DATA AT GUGULETHU COMMUNITY CLINIC

Folder number:

Date of form completion (dd/mm/yy):

Name and surname:

Date of birth (dd/mm/yy):

Male or female: M F

Age:

ID no.:

Address:

Relationship status: single with partner duration:

Income per month (in rands)

No. of children:

No. of economic dependents:

No. of people in the household: adults children

Housing: formal informal other

GIS reference:

Serviced? yes no

…gauge spoken at home:

Second langauge?

Probable route of HIV infection:
1. Heterosexual
2. Homosexual
3. Vertical (MTCT)
4. Blood products
5. IV drug user
6. Unknown

Level of education?
1. School: standard
2. College or university
3. Other
4. None
5. Unknown

Referred to Nomzamo by:
1. Self
2. False Bay Hospital
3. Ocean View Clinic
4. Other

Occupation status:
1. Employed - formal
2. Employed - informal or casual
3. Unemployed
4. Pensioner
5. Home-maker
6. Disability grant
7. Student
8. Other

Clinical information:

Height (cm):

Weight (kg)

Is patient pregnant? No Yes NA

On TB therapy now? No yes - start date:

…ate of first positive HIV test (dd/mm/yy):

Place of diagnosis:

Previous tuberculosis: No yes - date:

If yes, fully treated? No yes unknown

Date of last negative HIV test (dd/mm/yy): (if available)

Chest XR (baseline):
Date (dd/mm/yy): ________
1. Normal
2. Old tuberculosis
3. Active tuberculosis
4. Other pathology

Disclosure of status: (at first visit)
1. Nobody
2. Spouse only
3. Employer
4. Family
5. Community

Last pap smear (for women) (dd/mm/yy):

VDRL status: Positive negative unknown

Person completing form:

Appendix A shows the data form for collecting HIV/AIDS patient data at the Gugulethu HIV/AIDS clinic. The relevant fields were translated into the HIV/AIDS database.

APPENDIX B: HIV/AIDS PATIENT DATA

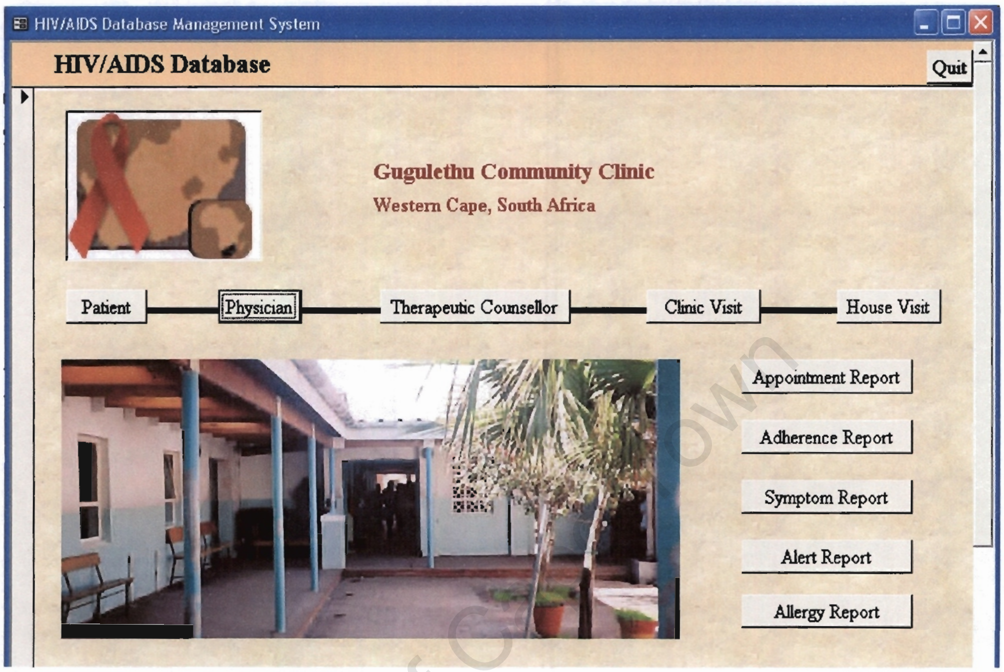
Appendix B shows the HIV/AIDS patient data obtained from the UCT Lung Institute. The data includes the patients' number, age, gender and stage of HIV. The CD4 count and the viral load of the patients are also provided.

Pt No.	week-2 CD4	Viral load	week 16 CD4	week 16VL	Age	Sex	Stage
MP001	245	500000	Died		42	Female	4
YB002	127	2611	192	<50	41	Female	2
MN003			Defer		31	Female	4
MP004			Defer		51	Female	4
MB005	10	33140	Died		31	Female	4
SM006	7	110804	Died		35	Male	4
JG007	204	108572	447	<50	28	Female	4
IS008	58	379887	143	<50	30	Female	4
NG009			Defer		37	Female	4
PM010	69	71328	197	<50	48	Male	3
FN011	115	38437	279	<50	43	Female	3
VS012	35	212027	193	<50	40	Female	3
SP013	20	60505	Defer		34	Female	4
TN014	139	174905	284	<50	28	Female	3
SM015	86	176511	186	<50	45	Male	3
MN016	194	227222	387	<50	33	Male	4
VN017	46	42011	110	<50	42	Female	4
TD018	120	427149	218	<50	38	Male	4
DB019	54	295048	182	<50	38	Female	4
NN020	73	73351	235	<50	36	Female	3
JJ021			Died			Male	3
KX022	15	207558	211	74	36	Male	3
VN023	162	81906	270	<50	41	Female	3
NM024	67	281913	340	340	34	Female	3
PM025	3	112356	113	494	34	Female	4
ZO026	100	276426	Died	Died	34	Female	4
FA027	124	173581	371	69	29	Female	2
NG028	37	35359	Perm defer	Perm defer	41	Male	4
XP029	83	500000	477	<50	24	Female	4
LC030	5	20977	32	<50	31	Female	4
NS031	192	5228	224	<50	29	Female	4
NC032	104	113375	Died	Died	27	Female	3
YF033	143	150000	411	<50	40	Female	4
LF034	60	58593	Defer		30	Female	3
LQ035	4	38889	185	522	35	Female	4
MM036	7	3875	140	<50	26	Female	3
MB037	213	25344	431	<50	40	Male	2

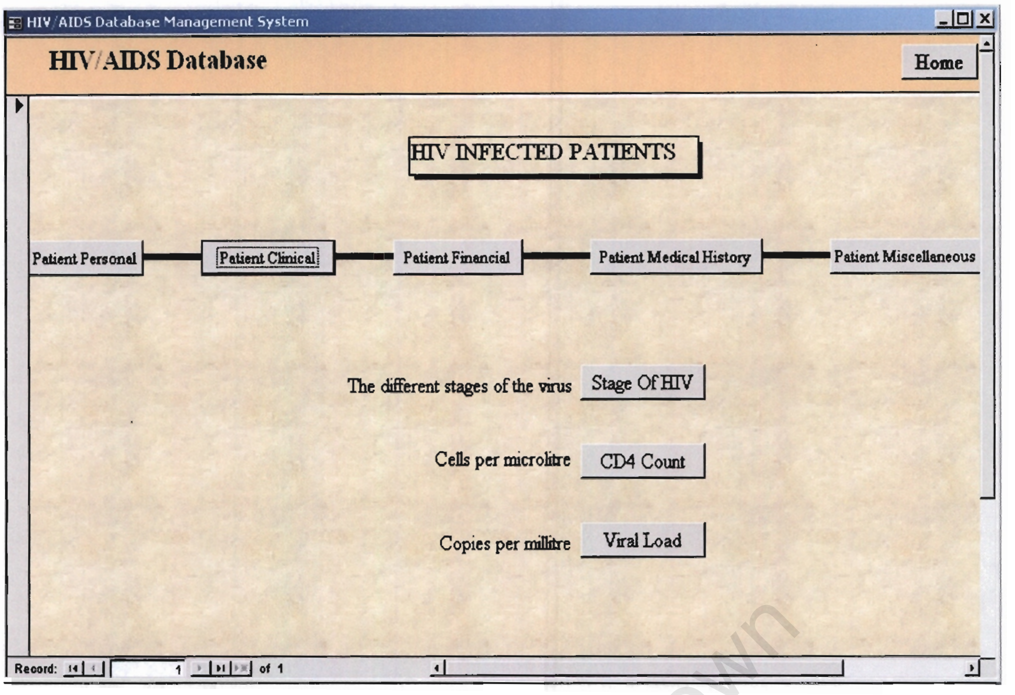
NB038	203	305554	555	<50	31	Female	3
PF039	15	122010	61	<50	32	Male	4
SB040	157	2786	230	<50	50	Female	3
NH041	117	42854	280	<50	24	Female	3
SX042	7	191490	147	<50	28	Female	4
NB043	42	181815	Died		42	Female	4
SB044	111	45313	204	<50	28	Female	4
MD045	46	500000	193	1669	32	Female	4
NQ046	209	38010	Defer		29	Female	3
TN047	22	500000	246	<50	32	Female	4
TN048	11	355981	died	died	40	Male	4
NM049	22	60352	295	<50	29	Female	4
NM050	155	44276	Defer		29	Female	3
MM051	Perm		Defer		32	Female	4
DG052	123	302086	92	<50	34	Male	3
ZS053	173	28732	232	<50	39	Female	4
TM054	51	38500	92	<50	31	Male	3
NP055	100	19001	167	<50	53	Female	4
LS056	147	62238	Defer		38	Female	4
PM057	60	124556	Defer		25	Female	4
CM058	77	103616			55	Male	3
CM059	83	9210	114	<50	31	Female	3
TM060	7	133796	53	<50	29	Male	3
GN061	84	127017			36	Female	4
KM062	12	187512			28	Female	3
NZ063	268		Defer		31	Female	2
TN064	23	431646			23	Female	4
BS065	22	500001	Died		31	Male	4
MC066	82	430070			30	Male	4
NN067	180	56433			34	Female	2
SL068	24	284981			50	Female	2
NS069	Perm		Defer		38	Female	
FN070	81	14109			36	Female	3
NS071	107	181678			31	Female	2
FG072	452	26135	Defer		39	Female	4
ZJ073	19	39800			35	Female	4
NB074	148	225907			37	Female	3
NK075					24	Female	3
BN076	Died		Died		28	Female	3
XF077	68	13678			7	Female	3
TS078	73	97518			38	Female	4
PM079	115	118819	Defer		34	Male	4
NW080	105	32031			30	Female	3
BL081	252	94040			34	Female	4
TS082	Perm		Defer		48	Male	4
NM083	174	264493	Defer		42	Female	4
TP084	Perm		Defer		30	Female	4
NA085	257	91622			40	Female	4
NM086	49	>500000			23	Female	4
GL087	24	>600000			38	Female	3
FM088	Died		Died		46	Female	3

AN089			Defer		24	Female	4
ZM090	15	119458	Defer		35	Female	4
LC091	76	112471			40	Male	4
WD092	24	92795			42	Male	4
NS093	167	46673	Defer		29	Female	
SZ094	27	487102			36	Male	4
NM095	134	87763			31	Male	4
MP096	31	452741	Defer		49	Male	4
NM097	34	284533	Defer		40	Male	3
BN098	117	161708			43	Male	3
LM099	44	426614			37	Male	4
AD100	93	47639			28	Male	4
MM101	294	7952	Defer		28	Male	3
NS102	319	38686	Defer		30	Female	4
BH103	275	149388	Defer		39	Female	4
NT104	52	11540			29	Female	3
PD105	119	130416	Defer		38	Male	3
MJ106			Defer		32	Male	4
JN107	132	12585			38	Female	4
NN108	54	66650	Defer		27	Male	3
NN109	132	12589	Defer		42	Female	3
TS110	146	55862	Defer		30	Female	1
PN111	153	188794	Defer		35	Female	3
MS112	232	20461			35	Female	4
MM113	23	120661			32	Male	3
BF114	110	139105			38	Female	3
ZN115	483	8114			31	Female	1
MS116	Died				23	Female	
NM117	14	212637			25	Female	4
TF118					37	Female	3
ND119	165	36027			31	Female	3
120	30	220310			42	Male	4
121	88	93677			36	Male	4

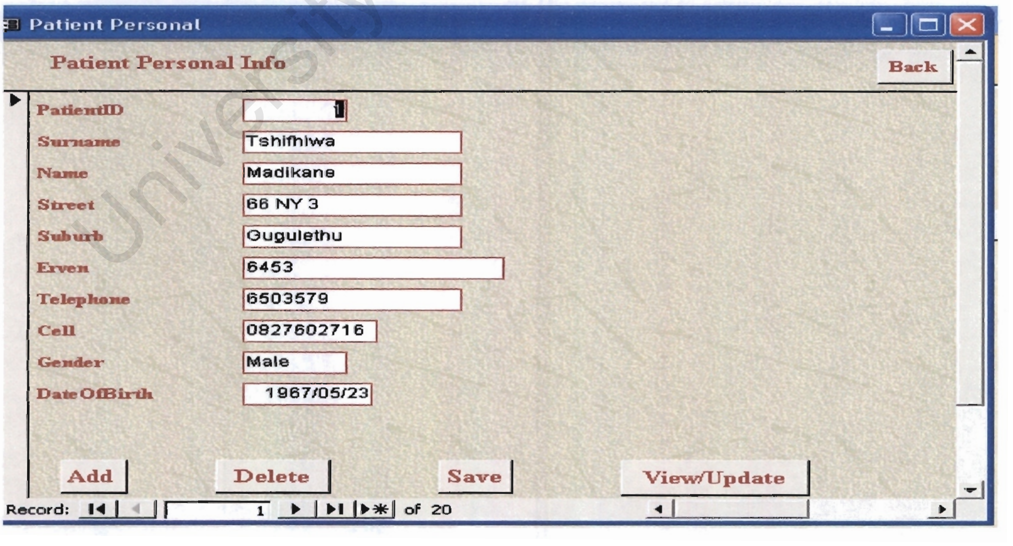
APPENDIX C: THE HIV/AIDS DATABASE



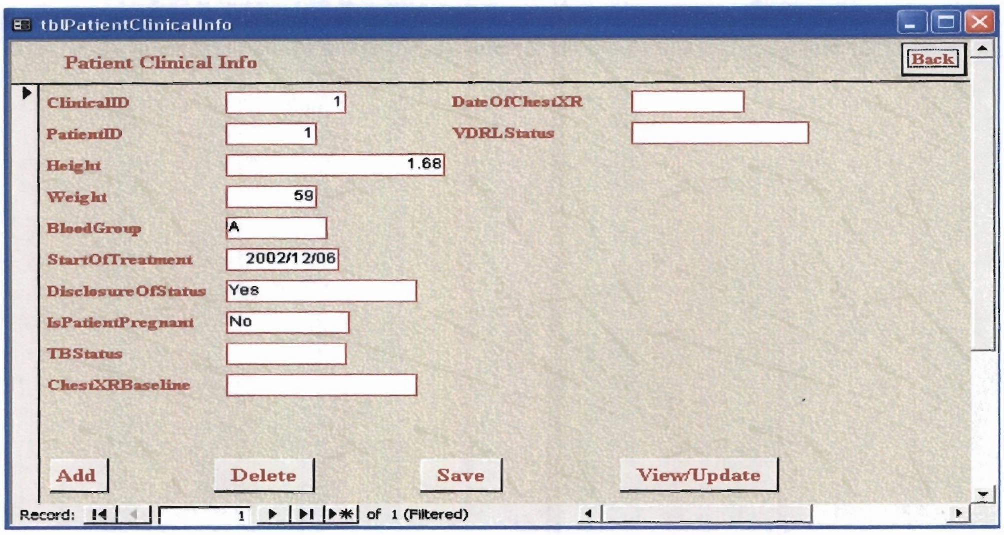
The main interface of the HIV/AIDS database is similar to a switchboard form whereby the users can click on any of the above buttons to view, update or even add records.



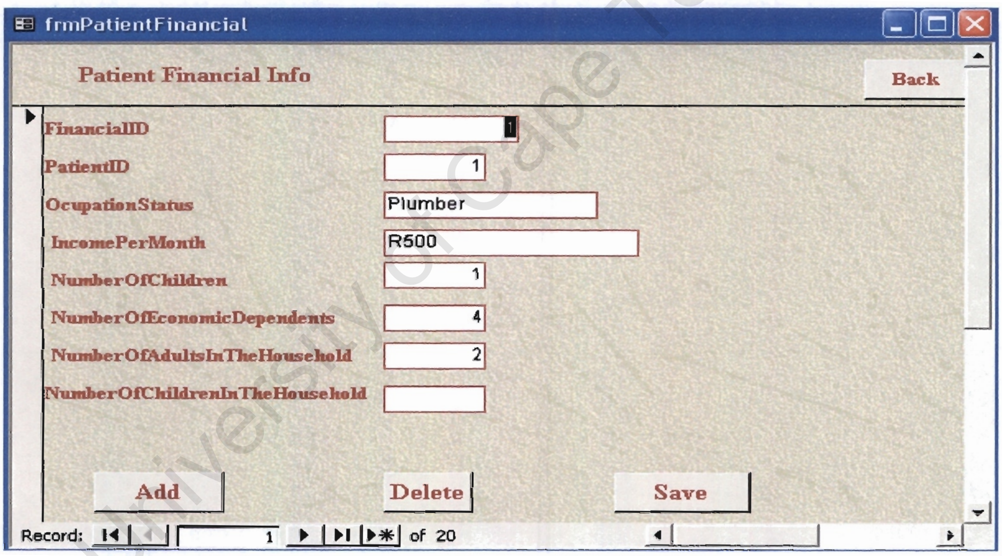
On clicking on the Patient command, the users are prompted with an 'HIV infected patients' interface allowing them to access further information about respective patients including personal, clinical, financial and medical information.



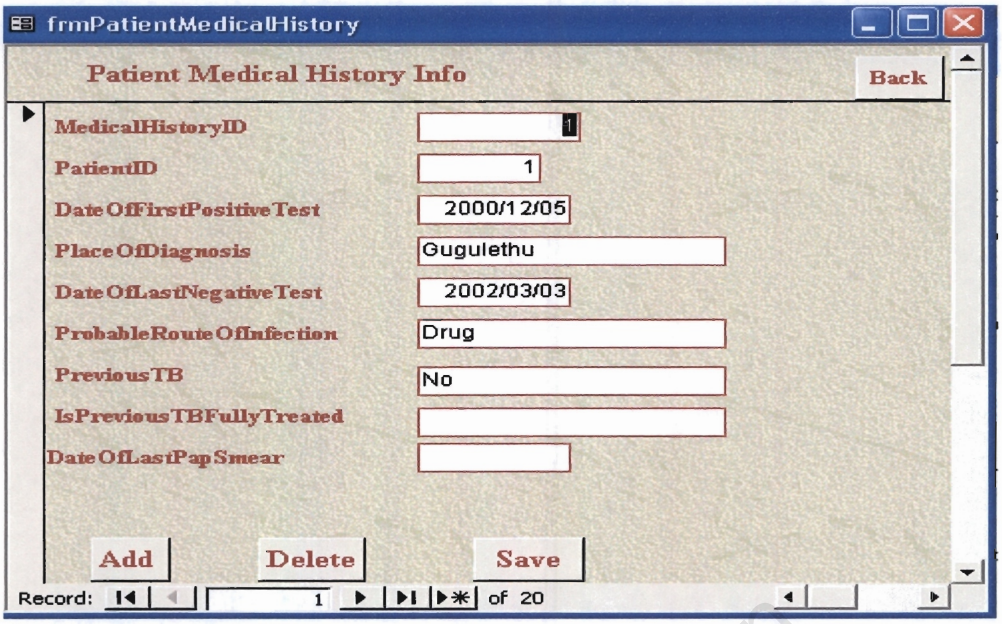
Records can be viewed, updated and deleted and users are also allowed to add and save new records.



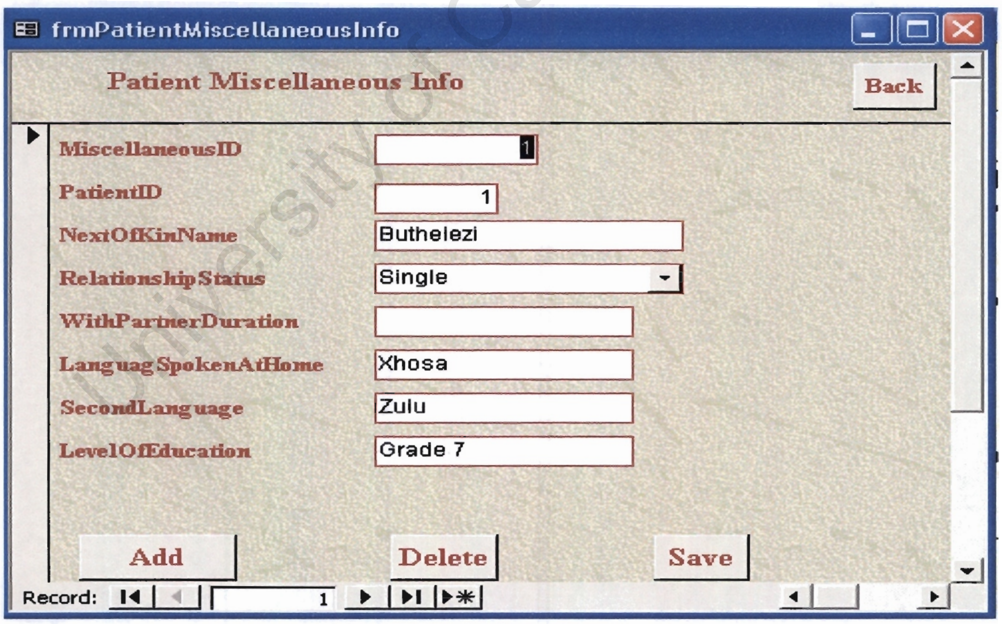
Records can be viewed, updated and deleted and users are also allowed to add and save new records.



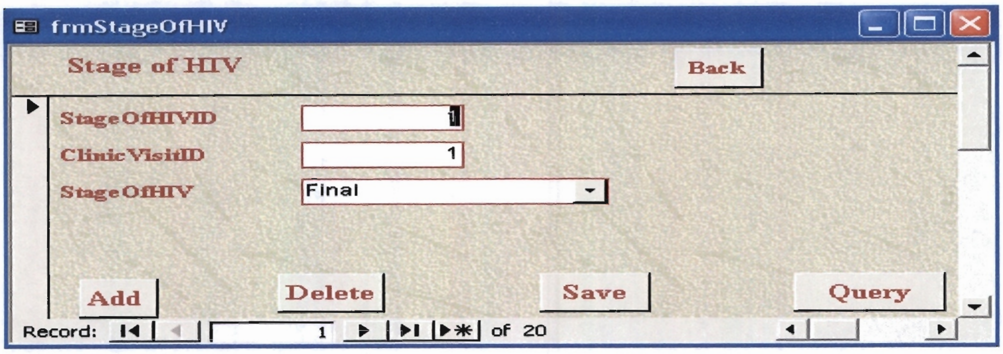
Records can be viewed and deleted and users are also allowed to add and save new records.



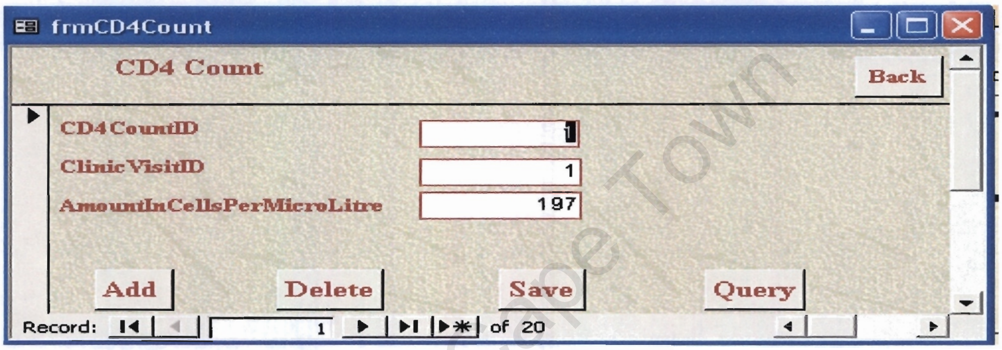
Records can be viewed and deleted and users are also allowed to add and save new records.



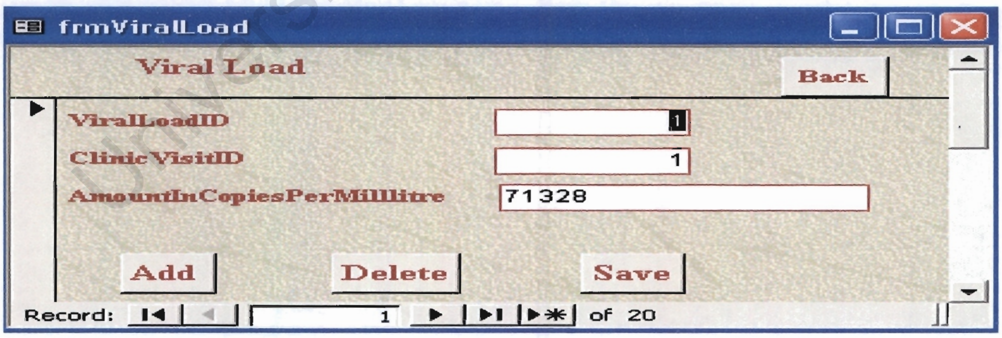
Records can be viewed and deleted and users are also allowed to add and save new records.



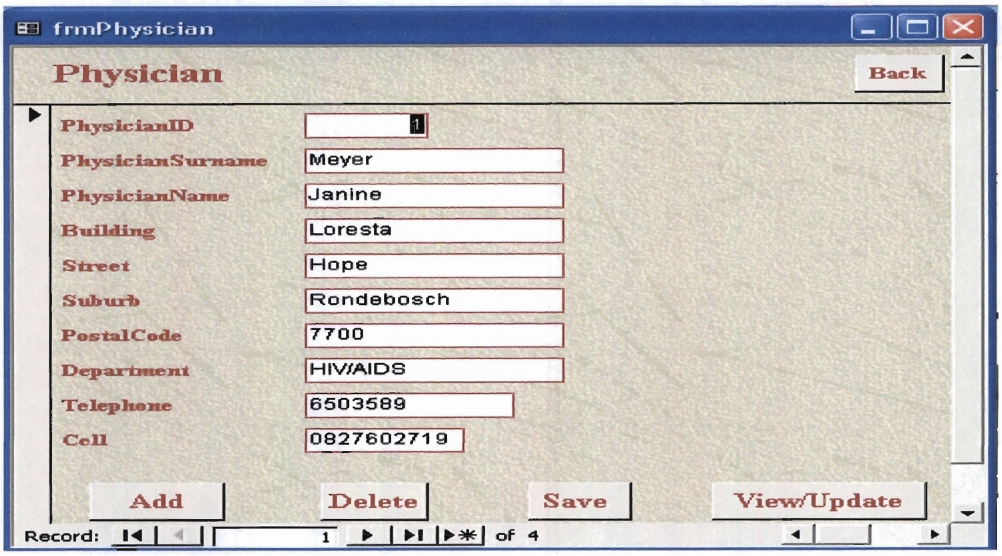
Records can be viewed and deleted and users are also allowed to add and save new records. Queries can also be carried out to compare the different stage of HIV against the different visit at the clinic.



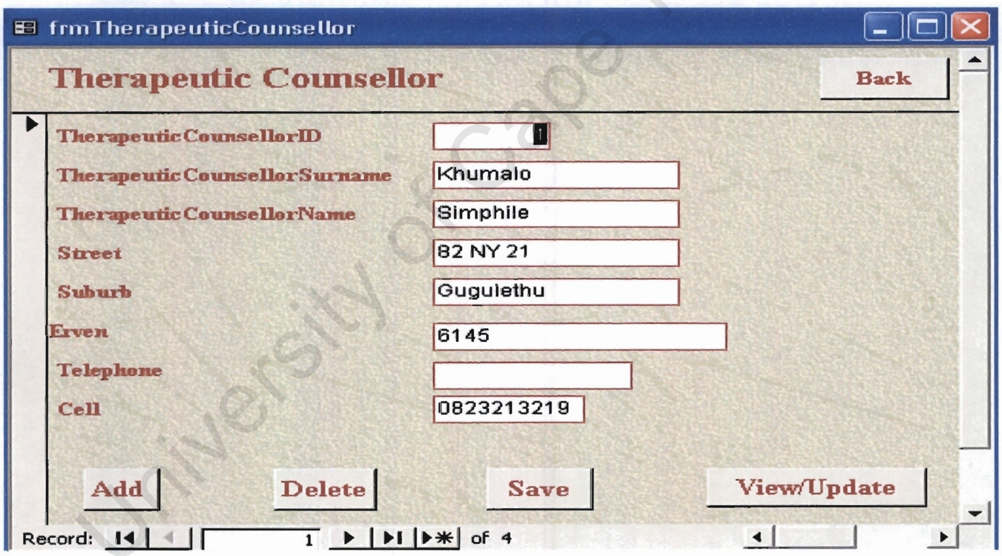
Records can be viewed and deleted and users are also allowed to add and save new records. Queries can also be carried out to compare the different CD4 Count against the different visits at the clinic.



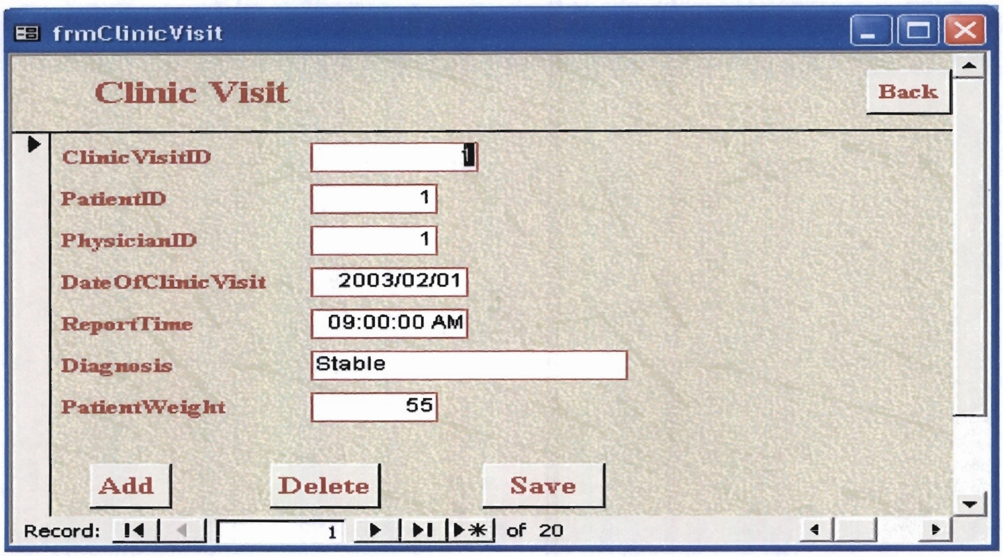
Records can be viewed and deleted and users are also allowed to add and save new records. Queries can also be carried out to compare the different Viral Load against the different visits at the clinic.



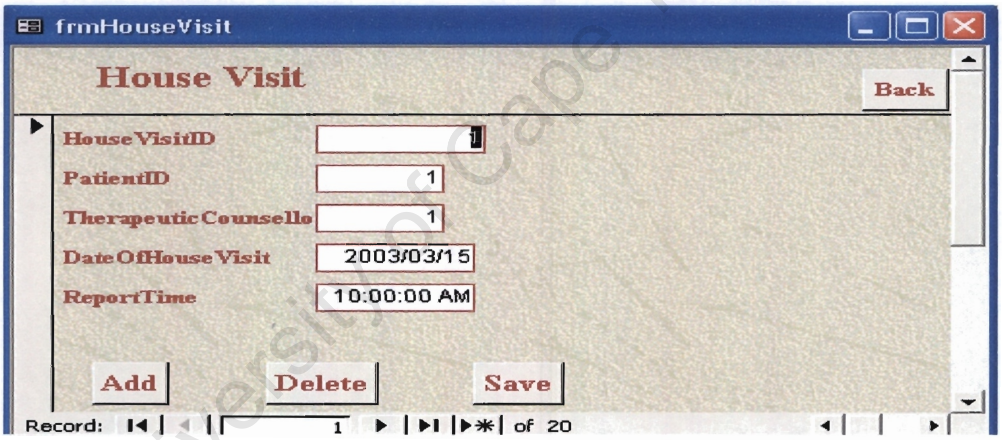
Records can be viewed, updated and deleted and users are also allowed to add and save new records



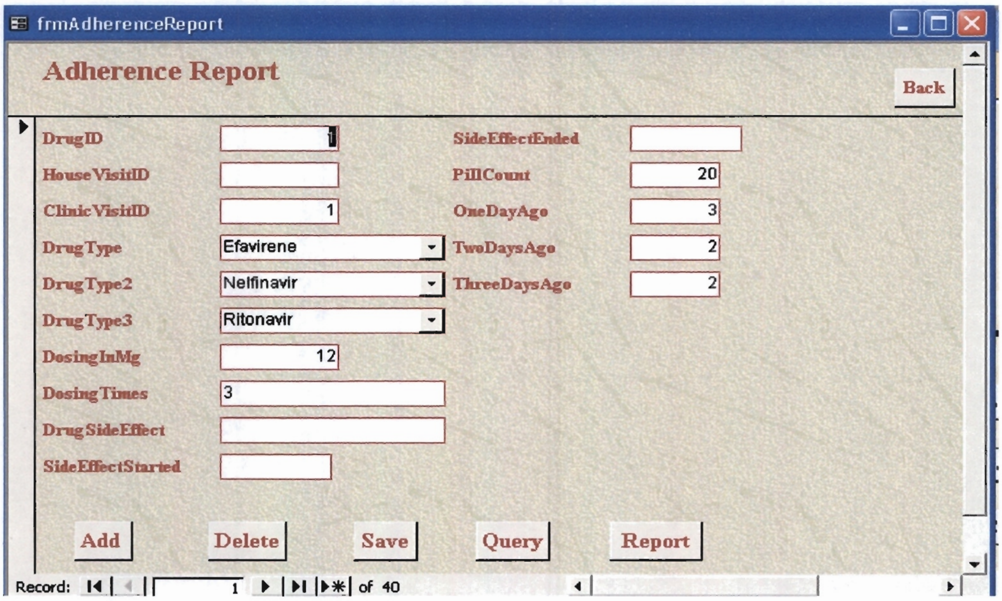
Records can be viewed, updated and deleted and users are also allowed to add and save new records



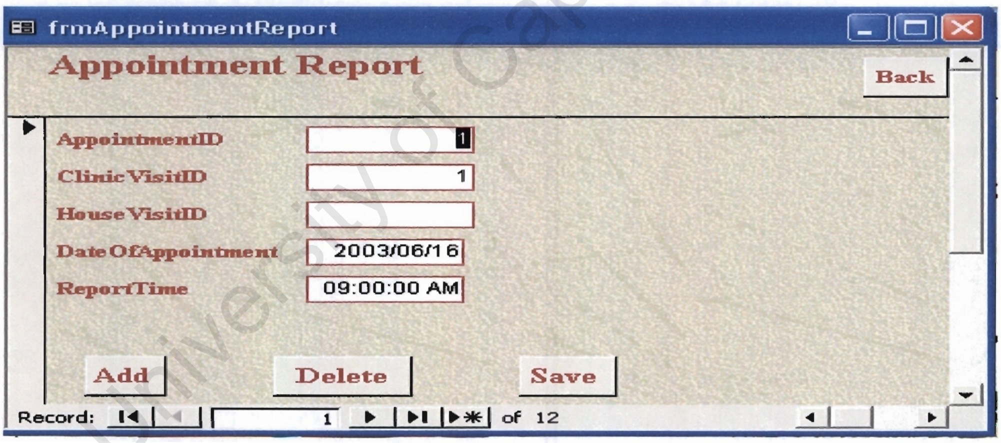
Records can be viewed and deleted and users are also allowed to add and save new records.



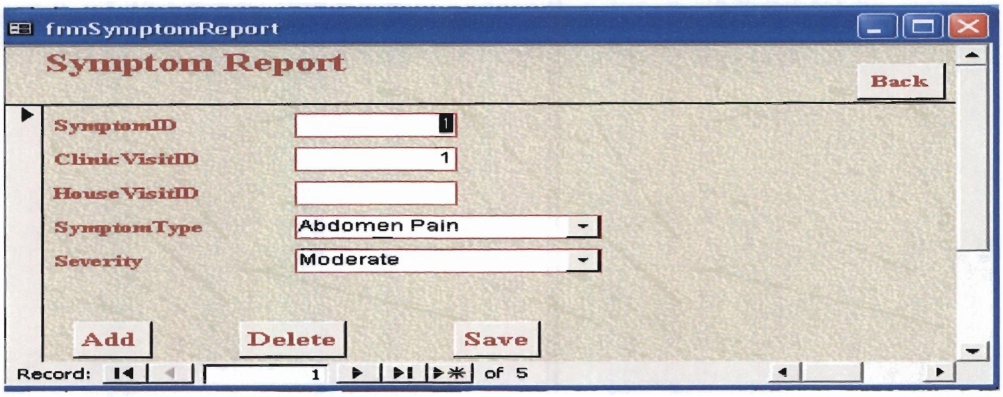
Records can be viewed and deleted and users are also allowed to add and save new records.



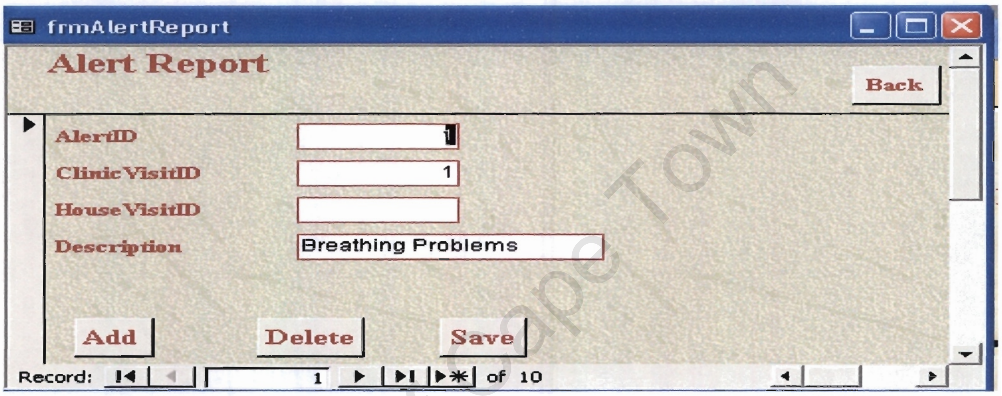
Records can be viewed and deleted and users are also allowed to add and save new records. Queries can also be carried out to monitor the adherence pattern of the patients. Clicking on the command ‘Report’ can generate reports.



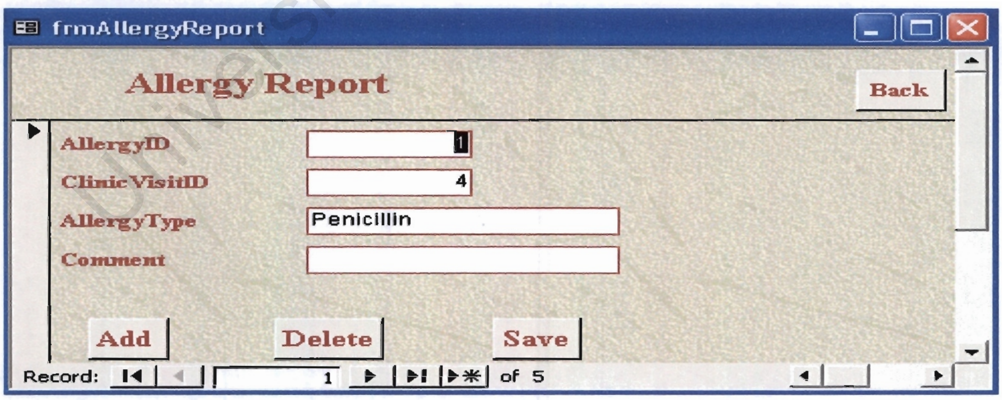
Records can be viewed and deleted and users are also allowed to add and save new records.



Records can be viewed and deleted and users are also allowed to add and save new records.



Records can be viewed and deleted and users are also allowed to add and save new records.



Records can be viewed and deleted and users are also allowed to add and save new records.

APPENDIX D: THE SIMS

The attached CD contains the HIV/AIDS database and the SIMS. To run the database, Microsoft® Access is required and the SIMS runs on ArcGIS 8.2.

On opening the CD-Drive, the user will be prompted to the HIVAIDS database and the SIMS folder. The SIMS folder contains the Gugulethu Shapefiles folder, the SIMS ESRI Arcmap document and the Spatial Information Management System database.

In case, the layers cannot be viewed in the SIMS ESRI Arcmap document, the respective layers can be added ( button) from the Spatial Information Management System database.