AN ADHERENCE MONITORING SYSTEM IN ANTIRETROVIRAL THERAPY

by

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OPTION: MANAGEMENT INFORMATION SYSTEMS

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DECLARATION

I, Otine Charles Daniel, do hereby declare that this Project Report is original and has not been published and/or submitted for any other degree award to any other University before.

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This Project Report has been submitted for Examination with the approval of the following supervisor.

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DEDICATION

To my Parents (Dr. and Mrs Otine H.M), thank you for not giving up
ACKNOWLEDGEMENT

Thanks to Dr. Ddembe Williams for your time and your patience.

And a big thank-you to Korina Akumu Otine for your indefatigable and often under appreciated support.

Thanks all else who made this research feasible.
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<th>Description</th>
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<tbody>
<tr>
<td>AIDS</td>
<td>Acquired Immune Deficiency Syndrome</td>
</tr>
<tr>
<td>AMPATH</td>
<td>Academic Model for the Prevention and treatment of HIV/AIDS</td>
</tr>
<tr>
<td>AMS</td>
<td>Adherence Monitoring System</td>
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<tr>
<td>AMSDB</td>
<td>Adherence Monitoring System Database</td>
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<td>ART</td>
<td>AntiRetroviral Therapy</td>
</tr>
<tr>
<td>ARVs</td>
<td>Antiretroviral drugs</td>
</tr>
<tr>
<td>CD4</td>
<td>Human T-Helper cells expressing CD4 antigen (T-Helper cell)</td>
</tr>
<tr>
<td>EMR</td>
<td>Electronic Medical Records</td>
</tr>
<tr>
<td>HAART</td>
<td>Highly Active Antiretroviral Therapy</td>
</tr>
<tr>
<td>HIV</td>
<td>Human Immunodeficiency Virus</td>
</tr>
<tr>
<td>MDM</td>
<td>Multi-Dimensional Model</td>
</tr>
<tr>
<td>MOH</td>
<td>Ministry of Health (Uganda)</td>
</tr>
<tr>
<td>NNRT</td>
<td>Non-nucleoside reverse transcriptase inhibitors</td>
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<tr>
<td>OLAP</td>
<td>Online Analytical Processing</td>
</tr>
<tr>
<td>PI</td>
<td>Protease inhibitors</td>
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<tr>
<td>PS</td>
<td>Patient Satisfaction</td>
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<tr>
<td>RUP</td>
<td>Rational Unified Process</td>
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<tr>
<td>UML</td>
<td>Unified Modeling Language</td>
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<td>UN</td>
<td>United Nations</td>
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<tr>
<td>UNAIDS</td>
<td>Joint United Nations Program on HIV/AIDS</td>
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<td>WHO</td>
<td>World Health Organization.</td>
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ABSTRACT

This study investigated the use of a Multi-dimensional system to improve adherence monitoring in antiretroviral therapy (ART). The high adherence levels required during patient therapy and the consequences of adherence failures (virus mutation to drug resistant strains, treatment failure, fatality) necessitated this study, with the hope that the development of a system would provide a basis for deployment of similar systems in other ART providing centers. An ART providing health centre (Mbuya reach out) was selected as a case study, with data collected from the centre used as a basis for the system design, development, testing and validation. Data was gathered through interviews, content analysis and direct observation; the rational unified process (RUP) of system development was then used to develop the system. Unified modeling Language (UML) was used to document the system development process, producing artifacts such as use case models, domain models, collaboration diagrams and System sequence diagrams.

The final system was entirely implemented in open source (MySQL and PHP) and hosted to an online web server with the findings revealing that adherence monitoring can indeed be improved by using the system, but there is still need for further research in protecting the data and the tweaking of the system to enable monitoring not only for adults but for children as well. It is recommended that leading ART providing centers in conjunction with Ministry of health champion the use of the system by training users to exploit the functionality of the system, and encourage use of the system with a goal of developing a comprehensive information base for future studies on adherence.
Chapter 1

INTRODUCTION

Antiretroviral therapy (ART) is the treatment of individuals infected with the HIV virus with pharmacological agents that have specific inhibitory effects on HIV replication (NYSDOH, 2005) [35]. The pharmacological agents are the Antiretroviral drugs (ARVs).

A Multi-dimensional architecture is one that allows multi-dimensional views to data. A multi-dimensional view provides the basis for analytical processing through flexible access to data.

1.1 Background

Since the first AIDS case was diagnosed in 1981 in the United States the disease has spread by enormous proportions in the world over, most especially in the financially weak countries of sub Saharan Africa (UNAIDS, 2004) [53]. In the case of Uganda the Ministry of Health (MOH) estimates the number of deaths directly related to HIV-AIDS to be over 940,000 at the end of 2001. To combat this threat to health care effort has been pooled from all available sources most prominent of which has been research in the medical field resulting in the introduction of Antiretroviral drugs (ARVs) which are used in Antiretroviral therapy (ART). Using ART, Patients can continue to live a normal life as the viral replication is continually suppressed by the ARVs.

"Administering and Monitoring therapy is crucial to the battle against HIV-AIDS in sub-Saharan Africa. Electronic Medical records (EMR) can aid in documenting care, monitoring adherence and drug response to therapy and providing data for quality improvement and research (Siika, 2005) [47]. At the onset of the AIDS scourge Uganda was one of the countries heavily affected with HIV prevalence rates of up to 30 percent. This high prevalence rate has been sub subsequently reduced to 6.2 percent over the last 19 years, and many reasons have been attributed to this and Uganda repeatedly praised for her effort (Richey and Haakonson, 2004 [45] and UNAIDS, 2004 [53]). The success against HIV-AIDS has been attributed to good leadership, massive education and awareness programs and more recently focus has been shifted to the provision of ART (Amolo et al, 2003) [2].
Introduction of ART to the fight against HIV-AIDS in Uganda dates back to 1998 when Uganda then was one of the pilot countries examining the provision of ART in low resource settings (PANOSAIDS, 2004) [38]. A pilot project that involved creating a National Drug Advisory board was created between 1999-2001 by MOH Uganda and UNAIDS, this board made recommendations on the provision of ARVs. At the end of 2000 MOH took over the responsibility of managing ARV treatment access from UNAIDS. This initiative to provide ARVs to the community resulted in the establishment, and growth of ARV distribution centers such as Joint Clinical Research Center (JCRC), Mbuya Reach-out HIV initiative, Nsambya, Mulago and Mild May specializing in pediatrics (MOH, 2003) [31].

There are four distinct classes of antiretroviral drugs: nucleoside and nucleotide reverse transcriptase inhibitors (NRTIs, NtRIs), the non-nucleoside reverse transcriptase inhibitors (NNRTIs), the protease inhibitors (PIs), and the fusion inhibitors (FIs). When formulating a highly active antiretroviral therapy (HAART) regimen it is recommended to use either a PI or an NNRTI in combination with two NRTIs. Antiretroviral therapy aims to suppress viral replication, restore or preserve immune function, Reduce HIV morbidity and mortality, improve quality of life and to limit the likelihood of viral resistance to future treatment options. Clinicians examine patients to determine whether they need to be put on ARVs, whereupon their treatment has to be closely monitored and evaluated, most especially their intake of the medication given. For optimal response to therapy, individuals have to take more than 95 percent of the prescribed medication (Read et al, 2003) [42]. This is a great stumbling block to antiretroviral therapy, especially in Uganda where the use of electronic medical records is limited or even non-existent in some cases. When a patient fails to adhere to ART, then there is the very real risk of the virus mutating and becoming resistant to further treatment, a situation that can end in tragedy.

This research focused on the feasibility of having multi-dimensional computer based information systems deployed at ART centers to assist in monitoring Patient adherence to ART, and also form a basis for generation of comprehensive reports on the status and operation of individual patients and ART centers. To generate information that is useful to decision makers, evaluations of hospital information systems need to be multidimensional, covering many aspects beyond technical functionality (Littlejohns et al, 2003) [25]. Adherence monitoring in ART can be looked at in two ways; discretely for each individual patient of the ART center or as a group depending on the different dimensions that a Patient could belong to, for instance age, sex, income, education level and so fourth. The multi-dimensional architecture for the proposed system not only ensures multiple ways of access to data but also the dynamic synthesis, analysis and consolidation of the data.

The ability to represent multi-dimensional views of corporate data is a core requirement of building a ‘realistic’ business model (Connolly and Carolyn, 2002) [8]. A multi-dimensional view of data provides the basis for analytical processing through flexible access to corporate data. Multi-dimensional structures are best visualized as cubes of data, and cubes within cubes of data with each side of the cube being a dimension. Ricardo (2003) [44] explains that a dimension represents a business process under which data analysis is to be performed and is organized in a hierarchy of levels, which corresponds to different ways to group its elements. A data cube therefore represents factual data
over which the analysis is to be focused and associates measures with coordinates, defined over a set of dimension levels. When a Multidimensional architecture exists users are able to synthesize organizational information through comparative customized viewing as well as an analysis of historical and even in some cases projected data. This has repeatedly been achieved using online analytical processing (OLAP) (Ma et al, 2000) [27].

This research examined the feasibility of having a computer based information system that is deployed at ART centers to assist in the monitoring of patient adherence to ART and form a basis for the generation of comprehensive reports on the status and operations of individual patients and ART centers. Focus was on formal based computer based information systems in the monitoring and management of antiretroviral therapy most especially adherence to therapy.

### 1.2 Definition of Key Theoretical Terms

**Adherence**: This is the degree to which a patient follows a treatment regimen or Prescription, (U.S Department of Health, 2005) [54]. The World Health Organisation (WHO) however has a more broader definition, stating that adherence refers to the extent to which a persons behavior; taking medication, following a diet, and/or executing lifestyle changes, corresponds with agreed recommendations from a health care provider (Eduardo, 2003) [14].

**Monitoring System**: This is a system that will continuously keep track of a dimension or dimensions and may give warnings in face of anomalies in that dimension(s).

**Antiretroviral Therapy**: This is the treatment of patients with pharmacological agents that have specific inhibitory effects on HIV replication (NYSDOH, 2005) [35].

**Adherence Monitoring System in Antiretroviral therapy**: This is a system that continually keeps track of a dimension(s) that indicates the degree to which a patient following his/her ART treatment.
1.3 Statement of the Problem

One of the most important issues in managing patients with HIV therapy is adherence to ART (Fairley et al., 2005) [16]. For treatment to be effective extraordinary adherence levels of up to 95 percent have to be maintained (Read et al., 2003) [42]. A stumbling block to ART is monitoring adherence to therapy; this has been made more complex by the manual technique of adherence monitoring and the ever increasing number of Patients on ART. The repercussions of failing to adhere to ART demands the need to have a Multi-dimensional system that improves monitoring patient adherence to ART.

1.4 Objectives

1.4.1 General Objective

The main objective of this project was to develop a Multi-dimensional System that improves adherence monitoring of different Patients at ART centers.

1.4.2 Specific Objectives

The specific objectives of this project were as follows:

1. To review existing literature on Multi-dimensional systems and Antiretroviral therapy.

2. To determine requirements for an adherence monitoring system.

3. To design a system that will aid management in tracking dispensation of ARVs to Patients.

4. To implement, test and validate a system that helps management to monitor levels of ARVs used by Patients.

1.5 Justification

The current system that was in place was not effective in monitoring the medical and social status of Patients of the ART center by reducing errors (Bates and Atul, 2003) [3]. There were incidences where the staff were unable to tell whether a Patient is adhering to medication which is of primary importance when it comes to ART. Eduardo (2004) [14] argues that the lack there of a system that addresses the determinants of adherence, means that advances in biomedical will fail to realize their potential to reduce the burden of chronic illness. Access to medication is necessary, but insufficient in itself to solve the problem. The system designed ensures that staff get warnings whenever variances in patient intake of the ARV is not and corrective steps can then be taken.

Littlejohns et al (2003) [25] states that to generate information that is useful to decision makers in health information systems, evaluations of hospital information systems have to be multidimensional, covering many aspects beyond technical functionality. A multidimensional system enable users to analyze data across any dimension at any level.
of aggregation with equal functionality and ease. A dimensional model for the system helped to present information to users as simply as possible, return query results to users as quickly as possible and above all helped to provide relevant information that accurately tracks the underlying business processes (Mundy et al., 2006) [34]. WHO (2006) [59] attests to the fact that giving of ARVs in combination, not only helps to reduce HIV replication and immune deterioration but also improve survival and quality of life. The multi-dimensional system ensures efficiency of distribution of ARVs to Patients and also helps to monitor ARV levels used by Patients.

1.6 Scope

This Project focused on developing a multi-dimensional system on Mbuya reach out HIV initiative. This ART center was one of the first ART centers to be established in Uganda and it currently has one of the highest number of patients, some 2000 patients (Reach-Out, 2005) [43]. The system developed is a prototype that can be used to develop other similar systems for other ART centers, that focused on monitoring patient adherence for adult patients and not including pediatrics care and treatment failure. The system assists management to monitor adherence to ART across dimensions such as age, gender, time, occupation and patient appointments. The project was executed over a period of four months.
Chapter 2

LITERATURE REVIEW

2.1 Introduction

This chapter takes a critical look at Antiretroviral therapy and adherence, Information systems and health care, Electronic medical records and Multi-dimensional models in health Informatics. Examples of implementations of Electronic Medical Records and Information Systems that support HIV Patient treatment shall also be highlighted. The chapter concludes by briefly looking at the characteristics and problems of adherence monitoring systems.

2.2 Antiretroviral Therapy and Multi-dimensional models in Health Informatics

Treatment of Patients infected with HIV-AIDS with pharmacological agents that have specific inhibitory effects on the virus is what is referred to as Antiretroviral therapy(NYSDOH ,2005) [35].Suppressing viral replication, reducing HIV morbidity and mortality, restoring immune function, and reducing the likelihood of viral resistance to future treatment option are some of the objectives of antiretroviral therapy. The pharmacological agents (Antiretroviral drugs) are given in combination, which combination is referred to as a regimen. There are several different options of the regimen, and if one regimen fails then a new one can be started and hence the reason why its important to preserve future treatment options for patients, thus ensuring that a patient always has some other option of treatment incase of failure of one regimen.

According to the HIV guidelines of MOH Uganda, the goals of treatment with ARVs are as follows:

1. Prolonging the life of HIV infected Patients.
2. Reducing the Patients morbidity.
3. Improving the quality of life of the Patients.

This is achieved by suppressing HIV replication as reflected in plasma HIV concentration to as low as possible and for as long as possible and by preserving and enhancing the immune function thereby preventing or delaying the clinical
progression of HIV disease (MOH, 2003) [30]. Patients on ARVs are therefore healthier and live a more improved life.

Patients are introduced to ART by putting them on what is known as a regimen, this is simply a treatment option consisting of a combination of ARVs. The only regimen that is potent enough to drastically reduce viral replication, prevent emergence of resistance and ultimately treatment failure for a significant amount of time has involved a combination of three antiretroviral drugs (MOH, 2003) [30]. This regimen is sometimes referred to as highly active antiretroviral therapy (HAART), and is normally formed by using a combination of a PI with two NRTIs or an NNRTI with 2 NRTIs. HAARTs have been associated with immunological restoration, slower HIV progression, durable therapeutic responses, improvements in the quality of life, and the prevention of emergence of drug resistance. The ARVs are not a cure for HIV but when used correctly can result in a higher quality of life for the Patients.

Adherence to ARVs have to be maximized for the optimal effects of ARV treatment. Adherence to therapy is a powerful predictor of response to therapy. For optimal responses to therapy, patients have to take more than 90 percent of the prescribed medication (Read et al., 2003) [42]. Patients have to try and take 95 percent of all their ARV medication, forgetting to take medication may lead to the virus becoming resistant to the treatment ending up with treatment failure and probably loss of life. Poor adherence to ART can cause the virus to resume its characteristic replication, providing the opportunity to generate virus resistant strains of the virus that may fail to respond to further treatment.

Durable suppression of the HIV virus to undetectable levels can be achieved in approximately 60 to 67 percent of the cases (NYSDOH, 2005) [35]. Maximal suppression of the HIV replication can be signified by increase in the CD4 count and reduction in HIV related symptoms. There are situations where undetectable levels of HIV replication can not be achieved, in such instances then a steady CD4 count may be used as an alternative goal. It is worth while noting that in complete viral suppression may be an indication of immunological deterioration and virus mutation. Patients who fail to adhere to ART are bound to face treatment failure and have fewer treatment options in future. The Patients have to be involved in the decision making process on whether or not to go on ARVs and on what regimen they should start on. The clinicians have to review the benefits and risks of each individual patient before recommending them for ARV treatment.

Read et al (2003) [42] reports on studies that show undetectable viral load in 78-84 percent of those who take 95 percent or more of their medication as compared to 45-64 percent who take between 90 and 95 percent of their medication. If less than 70 percent of the medication is taken then only 12-18 percent have an undetectable viral load. This goes to show how paramount adherence to ART is and how crucial it is that adherence be monitored as closely and as correctly as possible. Adherence can be done using electronic pill cap devices (Read et al,2003) [42], these are fitted on pill bottles and note the times when the cap is opened. This approach though is not practical for everyday use especially because of the expense. If poor adherence to ART is noted then it is preferable to halt adherence rather than risk mutation and resistance, ART can be resumed when the cause of non-adherence are identified and corrected. Some of the factors that have been closely related to non-adherence to ART include, drug abuse (especially alcohol), poor understanding between adherence to ART and resistance, depression or ambivalence to starting therapy.
According to Read et al (2003) [42] the following should be the clinical routine for improving adherence to antiretroviral therapy.

Table 2.1: Table 1: (Clinical Routine)

<table>
<thead>
<tr>
<th>Initial assessment</th>
<th>Initial Programme</th>
<th>Ongoing Programme</th>
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<tbody>
<tr>
<td>before starting ART identify those at increased risk of poor adherence by:</td>
<td>in all Patients before starting ART:</td>
<td>routine for all Patients on therapy</td>
</tr>
<tr>
<td>Depression or other mental illness.</td>
<td>Educate about link between adherence and preventing resistance.</td>
<td>Record self-reported adherence at every visit.</td>
</tr>
<tr>
<td>Drug or alcohol abuse.</td>
<td>Individualize medication schedule to Patient needs.</td>
<td>Intervene if this deteriorates.</td>
</tr>
<tr>
<td>Ambivalence about starting therapy.</td>
<td>Offer reminders, beepers, pill boxes, support people and perform trial runs.</td>
<td>Ask about side effects, and how the Patients are coping.</td>
</tr>
<tr>
<td>Poor understanding of importance to adherence.</td>
<td>Current stressors, crises, disruptions to routine.</td>
<td>Easy access to clinic between appointments.</td>
</tr>
<tr>
<td>Current stressors, crises, disruptions to routine.</td>
<td></td>
<td>Consider suspending therapy.</td>
</tr>
</tbody>
</table>

Adapted from MOH, 2003 [30]

The ARVs have to be sequenced in such a manner as to preserve future options. This is done to ensure that should one regimen fail then the client is still left with several options of therapy that can be started. Lastly the clients have to undergo resistance testing when appropriate and when it is available. This ensures that any signs of resistance (mutation) of the virus can be noticed early and corrective steps taken to address this situation. In spite of the ART good practices outlined, ARVs have the following limitations

1. The potency of the drugs may be reduced by Drug interaction and drug resistance.
2. Adverse drug reactions may occur in some Patients.
3. Even with price reductions ARVs are still expensive.
4. Adherence is key to successful ART.
5. Eradication of HIV from the body is not possible at present, as such the medication have to be taken for life.
6. Despite doing everything right, some patients may not respond to treatment.

HAART(Highly Active Antiretroviral therapy) is recommended when:

1. Patient related barriers to adherence are minimized.
2. Patient is symptomatic from HIV.
3. CD4 Cell counts are less than 350 cells per mm3.
4. Other AIDS-defining conditions are present.

MOH Uganda has collaborated with WHO, UNAIDS and other partners both local and international to develop a comprehensive care program for HIV people. Until recently the focus on the use of ART had been limited due to the high cost of antiretroviral drugs (Mugenyi, 2004) [33]. The significant reduction in these drugs and the positive international response to make ARVs accessible in low resource settings like Uganda has resulted in increased emphasis on ART.

The term Health Informatics is defined by the British Medical Information System (2004) [5] as the understanding, the skills and tools that enable the sharing and use of information to deliver health care and promote health. It involves the application of information and communication technologies to enhance health care ending up with an intersection of health, Information, computer science, psychology, epidemiology and Engineering. This research focused on the synergy between health, Information and computer science. Health Informatics assist doctors, nurses, and other public health workers to better address today’s problems. Patients and their families are better informed and better cared for through health Informatics by among other things detecting and managing the effects of disease through Information management and technology based communication tools.

Multidimensional models are models that use the multidimensional structure, whereby the data is physically stored in array-like structures that are similar to a data cube. In the relational structure the data is stored in a relational database using a special schema (star or snowflake) instead of a traditional relational design. In multidimensional data analysis a decision maker needs summary data related to a specific subject and he/she must consider that data with respect to certain factors. Summary data are usually numerical and measurable. Therefore, the attributes representing them are often called measure attributes. The factors on the basis of which summary data is analyzed are called dimensions, represented by dimension attributes (Ranjit,2006) [41]. These models can be used in health informatics to provide the basis for analytical processing of health data through flexible access to the data.

Singh (1990) [49] noted that there is an apparent consensus in the literature that Patient Satisfaction (PS) is best represented as a multidimensional construct with evaluations influenced by three primary sources: physicians, other care givers, and insurance providers. Adopting the multidimensionality perspective of PS, Linder-Pelz (1982) defined PS as positive evaluations of distinct dimensions of the health care that a patient has received. The care being evaluated might be a single clinic visit, a treatment throughout an illness episode, a particular health care setting or a plan.

Hence, it is suggested that there are two parts to the definition of PS: expectation and experience. To define and assess PS, many authors use expectation versus perceived experience methodology along the multidimensional lines. This is an attempt to capture the process through which patients evaluate quality of health care from their own perspectives. In simple encounters, the patient enters the situation with expectations, and the perceived difference between expectations and experience offers net satisfaction; if experience is greater than expectations, the experience is satisfactory (Steiber and Krowinski, 1990) [50].
2.3 Health Information System and Antiretroviral therapy

The potential for utilization of computers as part of information systems in the business environment was realized as early as the 1960s. The first applications were mainly aimed at automating existing tasks (Watson et al, 1991 [58]; Willcocks, 1989 [61]). As computerization evolved, systems were designed to support the management of organizations. The earliest approach was the introduction of Management Information systems (MIS). These systems were operated by system professionals and were used to generate regular, predefined, reports containing information about organizations (Millet et al, 1991) [29]. These systems are often based on transactional processing systems that collect the data from the business functions whereupon this data is analyzed to generate information for managers to better carry out their responsibilities.

The application of computer technology in health care is by no means new (Paul, 1997) [37]. In the past, computer use in the health care had been mainly concentrated in the use for acute patients, however, this is changing and more and more computers are being used in ambulatory care. Lyle et al (1995) [26] argues in the journal paper on how management information systems can be used to enhance the health care quality assurance. In this paper, the authors argue that the sheer volume of information generated during patient care calls for computer systems that can be capable of handling the vast volume of data and analyzing the data to aid in the decision making process. They further argue that the computer systems must be capable of issuing out alert reports that identify potentially dangerous events in individual patients so corrective actions can be taken to address this in time. These alerts provide safety nets for quality patient care, this could be put to use in monitoring patient adherence to ART whereby any evidence of patients defaulting on treatment is immediately red flagged. It is important to highlight that this paper also argues that the use of manual collection of this data is inappropriate. This school of thought is also shared by Mari et al (2003) [28], this is in response to a study that shows that an Electronic reminder issued at the point of care can influence physicians behavior and increases the likelihood of patients receiving preventive interventions.

In Uganda, ART centers give ambulatory care to their patients. Studies have been conducted to show that the use of computers can impact ambulatory treatment in a positive way. Daniel et al, (1997) [11] reports on the effectiveness of computers on ambulatory quality of care. This paper shows how an online interactive, real time system management information system improved the quality of care. Since ambulatory care places even higher demands on the health care process, only computers have the necessary data handling capabilities to meet the quality issues of health care in this setting (Lyle et al, 1995) [26].

Much needs to be learned about AIDS and computers can effectively improve the quality of care while at the same time increasing the base of knowledge for the disease (Lyle et al, 1995) [26]. By developing Multi-dimensional systems for ART centers, we can build an Information base for HIV/AIDS relevant to an area and help increase knowledge about the disease. Julia Hidalgo from Mary Land Department of Health reports of a computer system developed by the state of Maryland in the United States to evaluate a variety of health and social services for AIDS patients. The system can measure the impact of new drugs on the clinical courses of patients, examine the cost and effectiveness...
of anti-infective agents, determine the need for additional long term care and hospital services, as well as assess the impact of health care insurance on levels of utilization.

ART does not only stop at the distribution of Antiretroviral drugs but also goes a step further in educating the patients on use of the drugs, adherence tips, feeding and living a positive life. Studies have been conducted to show how the use of computers and computer information systems can be used to enhance patient education (Deborah, 1999) [12]. The author describes how computers have been used in patient interviewing with results, notably was the response to use computers especially on obtaining information on personally sensitive information. These programs were designed to deliver both customized interviews or individualized patient information. Specially noted was the program 'diabeto' that was being distributed by a videotext network in France. Using this program, a patient could have access to decision support, email and an information component. Making the system online enhanced collaboration between members (patients or clients) and also enabled easier information sharing. Using the system care givers of patients with AIDS appreciated the systems access to private support and consultation.

Surveillance for Human immunodeficiency virus (HIV) or other notifiable diseases generates information that can be used at the national and sub national level (Carla and Ties, 2005) [6]. The author states that at the individual and community level information is needed for the effective clinical management and for assessing the extent to which services are meeting the needs and demands of communities. Further higher up the levels we could have the planners and managers make decisions about the effective functioning of health facilities and of the health system as a whole. At even higher levels the information is needed for the strategic policy-making and resource allocation. Mapping this specifically to the Ugandan situation, the information generated from the grass root ART centers would be used at different levels in this country, where at the top most the donors and government could use it during policy-making that precisely addresses the Ugandan situation. Tasks such as adherence and client response to ART monitoring, ART center performance monitoring can be more easily and quickly done by staff at the ART center. However we need an efficient and effective system for the collection and analysis of this data especially if it is to be available in time when needed and accessible as well.

2.4 Health Monitoring Systems

Diaz-Buxo et al, 2003 [13] reports on the evolution of a monitoring system for patients who suffer from dialysis. In the beginning the monitoring was manually done with patients being observed for vital signs by a caretaker. As advancements in technology progressed the monitoring process also developed with the incorporation of computers. The concept for computerized treatment monitoring for dialysis started in the clinical environment in the 1970s (Diaz-Buxo et al, 2003) [13]. In the United states and Canada systems for monitoring dialysis have been developed and set up where an observer can monitor several patients from a centralized location, this works by having patient information sent back to the observer in real time using telephone/modems or the Internet. The Patient information is collected using hemodialysis machines at the patients home before transmitting the information using a designated channel back
to the monitoring center. The newer monitoring systems for hemodialysis have incorporated alarms for the monitors and the alarms are recorded, time stamped and documented as well.

There is also ongoing research on devices that Patients can wear or even in some cases that can be implanted on the Patient to help monitor specific patient conditions (Bennett et al, 2005) [4]. These sensors continuously collect data from the patients who may be at home or at a clinic and transmit the information back to a secure network server. A physician can then access the records from a computer connected to the Internet at their convenience. This idea has been examined using hemodynamic sensors to monitor heart failures in patients. Bringing this into the context of Uganda, this approach would have high cost implications not to mention the poor infrastructure that exist for transmission of the collected data back to a secure server.

Monitoring of patients with heart conditions using smart phones and biosensors is discussed by Leijdekkers and Gay 2006 [24]. The data from the patient is monitored using the smart phones and sensors, when anomalies are noted then the information can be used to take a corrective action. For instance the sensors could call an ambulance for the patient or offer the patient advice for example to exercise some more. This system can also be used to store personal data for the patient in addition to collecting the data from the heart monitoring, personalization of the devices to individual patients is also feasible. Data can typically be transmitted back to the health care centre for analysis using wireless connectivity for example General Packet Radio Service (GPRS). The system discussed by Leijdekkers and Gay (2006) [24] is more advanced in that a patient’s location can be established in case of an emergency automatically, for instance it can determine whether a patient is inside the house or outside.

Many a times patients and their health care givers are not in the vicinity of each other, this therefore calls for some form of remote patient monitoring. Mohammad et al 2006 [32] and Kogure et al 2005 [21] discuss the use of information systems that supports remote patient monitoring. In the former’s approach many physicians can monitor a single patient from varying locations as a result of web access of patient information remotely using a system called Virtual Eye (VI). The system placed an emphasis on security of the patient information and the use of GSM network to alert the doctor incase of anomalies in the patient’s vitals. Kogure et al 2005 [21] reports on the development of a monitoring system for patients using java-enabled mobile phones, with a bias on the transmission of data to the physician’s mobile phone. The argument being that the larger the amount of information about the patient that the physician has to make a decision on the patient’s status the better. The authors propose an architecture for the system but fall short of full implementation leaving this aside for future development. The web server utilized is apache web server with PHP being used as the main programming language. Using data from the patient the program is able to plot simple graphs on the status of the patient. The main problem faced by the system is the speed in terms of the plotting of the different graphs and the time that it takes to download the images plotted on to the mobile phones.

Patient self reporting has been used repeatedly as an adherence monitoring technique. This is where the patients actually take time to record on a sheet of paper when they take the medication prescribed to them. This is can then
be used to check whether or not they are adhering to the therapy. There has also been use of electronic pill caps, whereby the pill caps electronically take note of when the caps are opened, the main assumption is that each time the cap is opened signifies the Patient taking their prescribed medication. This mode of adherence monitoring however is expensive and may not be practical in a poor resource settings. This research aims to find a technique that uses the patient self reporting method in conjunction with computer based information systems to improve the efficiency of adherence monitoring. By employing the Multi-dimensional approach, the patient adherence can be examined basing on the different dimensions that a patient could possibly belong to.

2.5 Implementations of Electronic Medical Records and HIV Information Systems

Electronic medical records (EMRs) are computer based patient record. EMRs help to facilitate access to medical records at any given location, the building of automated checks to allergy and drug interactions, clinical, notes, prescriptions, scheduling and the reviewing of laboratory reports. The main disadvantage of EMRs is that they are susceptible to privacy invasions, however with the proper legislations and checks in place, this can be mitigated. Five levels of an Electronic Health care Record can be distinguished:

1. Automated Medical Record: This is a paper based record with some computer-generated documents.
2. Computerized Medical Record: This makes documents of level 1 above electronically available.
3. Electronic Medical Records: Restructures and reorganizes the documents of the two previous levels ensuring enteroperability of all documentation systems.
4. Electronic Patient Record: This is a Patient centered record with information from multiple sources
5. Electronic Health Record: This one adds general information to the EPR, which information may not be necessarily related to a disease.

An example of an implementation of an EMR is the National Health Service(NHS) of the United Kingdom, with a goal of having 60,000,000 patient records by the year 2010. Another prominent example of an implementation of an electronic medical record system is the province of Alberta’s Alberta Netcare (Aberta Netcare,2006 ) [1] this provides an integrated electronic health solution that will be accessible by health providers. This will help to link pharmacies, clinics, hospitals and other point of care to patient information. Alberta Netcare puts a strong emphasis on security, by enforcing authentication using logins and access levels, furthermore the shared information is encrypted using ISO 17799 Standards. There are also other security checks like firewalls, intrusion detection systems and other high quality network security checks.

Silka et al, 2005 [47] reports on An Electronic Medical record system for ambulatory care of HIV-infected patients in Kenya. The development of this system dates back to 2001 when Moi University in collaboration with other stakeholders established the Academic Model for the Prevention and treatment of HIV/AIDS (AMPATH). This was
the first organization that came up to offer ambulatory HIV/AIDS in Kenya including antiretroviral therapy. Prior to the establishment of AMPATH the Moi University in collaboration with Indiana University had implemented an Electronic medical record for ambulatory care in rural Kenya, it being the first in sub-Saharan Africa (Hannan et al, 2000 [18]; William et al, 2003 [62]), this system demonstrated that an electronic record system was plausible and could be maintained in a poor resource setting, though it did not concentrate on those infected with HIV/AIDS.

The advent of AMPATH Electronic Medical record system (AEMR) saw more focus on the HIV/AIDS patients, with the system being maintained centrally while information was capture on paper at the different locations (health centers) and driven back to the headquarters and manually entered into the system. The main drawback with this approach was the failure to support real time entry of data into the system and situations where there was poor road infrastructure would mean a disruption in the flow of information. The system was also developed in Microsoft Access and Visual basic which at the time was most appropriate, but as of now the changes in technology and development calls for more robust programming languages and better database management systems that could even support web based entry of data. This would enable the capture of more complex information about the patients that would enable better analysis and research to be carried out on the databases.

The use of an information system and medical record to support HIV treatment has also been reported in Haiti (Hamish et al, 2004) [17]. The development of an electronic medical record to support HIV treatment was based on a web-based electronic medical record previously developed for tuberculosis. Patient information can be searched and data downloaded to statistical analytical packages. This system also ensures supplies of drugs are kept at a level to meet patient needs as required. The system uses complex encryption to ensure that the patient information is kept confidential, further more interactions with the system is logged and staff encouraged to use complex passwords. This system however fails to address the emphasis on adherence management of ART to patients.

2.6 Characteristics of Adherence Monitoring Systems

While a standard approach to measuring adherence lacks there are afew characteristics shared by systems that monitor adherence to treatment. Adherence monitoring systems normally measure the number of doses of medication that have been missed by a particular patient. This can be achieved in a number of ways:

Patient self reporting is one approach where by patients keep tabs on how they themselves are taking the medication given to them. This is normally done using self report questionnaires, Poppa, 2003 [40] argues that this approach enables the patients to be more involved in their own treatment. Adherence can also be monitored through health providers by carrying out an analysis of their estimates.

Adherence monitoring systems are also characteristic in that they may monitor patient adherence to medication by analysing drug levels in the patients blood stream (Poppa, 2003) [40]. With this approach periodic blood tests have to
be carried out on patients who are on medication. Another characteristic is the use of MEMScap (Medication Event Monitoring System). This infer that if a medication bottle is opened then medication has been taken by the patient. The system in place therefore monitors the opening and closing of the medication bottle and inference can then be drawn from this. Other methods such as pill count also exist.

2.7 Problems of Adherence Monitoring Systems

Different systems have different approaches to monitoring adherence. As such they also have a wide range of problems that face them. For example systems that use MEMScap have problems of cost and infrastructure, furthermore using this approach makes it difficult to monitor the adherence to medication that needs to be taken on a weekly or the use of blister packs [40]. Systems that use patient self report are also susceptible to fabrication by the patients who are monitoring themselves.

In the context of sub-Saharan Africa where we have very basic and under developed IT infrastructure the analysis of health care provider estimates may be difficult, more so because of poor record maintenance. Pill counts may also be time consuming for the ART givers and must rely on the fact that patients come back with their medication containers each time they visit the clinic.

2.8 Conclusion

It is evident that patients undergoing any therapy let alone ART need to have their progress carefully monitored. The use of information systems to address patient monitoring is not new and has been used in cases where patients are suffering from diseases ranging from heart conditions to diabetes (Mohammad et al, 2006 [32]; Bennett et al, 2005 [4]; Kogure et al, 2005 [21]; Leijdekkers and Gary, 2004 [24]). Though not a complete cure for the HIV virus, antiretroviral drugs have given hope to those infected with the virus. There are however still many problems encountered during therapy including but not limited to high costs of the drugs, access to therapy, treatment failure and adherence; even then effort is being made to address these problems. Insight from the above implementations of information systems in monitoring patients on other therapies can be used to implement a similar system dealing with patient monitoring under different scenarios.

This research will therefore aim to tackle the problem of adherence by creating a synergy with information systems, thereby improving the dispensation of ARVs to patients, checking the ARV levels utilized and improving the monitoring of patient adherence to medication prescribed which is paramount during therapy. It is also feasible that the results could be extrapolated to monitor adherence for other therapies not only ART.
Chapter 3

METHODOLOGY

3.1 Introduction

This chapter examines the steps taken in achieving the objectives of this project. It examines the methods used to collect and analyze data, it also shows the process and tools used in designing and developing the proposed system. The rational unified process of system development was looked at in detail, it being the methodology that was used in the design and implementation of the system.

3.2 Data Collection

This section looks at the methods used to gather the data for the research and how the analysis of the data was carried out. The study relied on three methods of data gathering namely; interviews, observation and content analysis. Data was collected primarily using interviews. This was necessary especially in the gathering of the requirements for the system under design.

3.2.1 Interviews

An interview is a direct face-to-face attempt to obtain reliable and valid measures in the form of verbal responses from one or more respondents. It is a conversation in which the roles of the interviewer and the respondent change continually. Interviews where scheduled and carried out with different stakeholders of the ART reach out center, ranging from the Director to the receptionist. This helped to determine the different roles carried out by these people in the organization, their main goals of the current system and their expectations of the proposed system. This was paramount in that it enabled the researcher to model the use cases and finally the user requirements.

Interviews are crucial in that they act as effective tools in gaining insight into the major problems and at the same time help offer solutions or improvements to these problems hence being important in the evaluation process. Evaluators are able to form relationships with those being interviewed helping the evaluator get first hand knowledge on the problems forehand, as such trust is very important during interviews. To achieve this the researcher scheduled the
interview forehand and went sought permission from the Director of the center. The director and each of the those being interviewed were then informed of the objectives of the project and the purpose of the research, thus ensuring that they had a fairly good understanding of what the interview and indeed the research was all about.

Potential problems with interviews include missing certain crucial information from the interviewee during the interview as they speak. This was mitigated by having a research assistant present to assist with taking notes and also having a tape recorder present during the interviews. Furthermore the researcher made an effort to go over the key issues of the interviews by giving a brief summary of the interview and offering the interviewee a chance to concur or not.

3.2.2 Observation

Direct observation of the work performance was also carried out to help in data gathering. The observations were arranged well in advance in collaboration with management and the workers were made aware of why they were being observed. One of the staff involved in monitoring and evaluation was also involved in the observation and helped to clarify on some of what was being carried out in the event of need for clarifications. Observation is normally done in collaboration with other data gathering methods to help ’fill’ in the blanks, in this case the alternative method were interviews. This approach helped the researcher identify a gap that would be filled by the proposed system.

3.2.3 Content Analysis

Almost all organizations maintain records, such is the case with most ART centers including mbuya reach out HIV initiative on which this research was based. These documents include patient medical information, prescription information, drug information, drug orders, patient appointments and test results. A review of these documents provided a valuable information to substantiate the performance deficiencies under consideration. The challenge during this phase was determining which data was relevant and whether the quality was adequate.

The Researcher made an effort to understand from those responsible at the ART center how the data was collected (for example in the case of patients, personal information was obtained by asking them specific questions) and its meaning. Compliance was also adhered to as per the clients instructions, for example patient medical records are confidential so only the researcher interacted with patient records. Effort was also made to ensure that the data used was up-to-date and correct by trying to confirm the information from other sources available.

3.3 Unified Modeling Language

The Unified Modeling language (UML) is a language for visualizing, specifying, constructing and documenting the artifacts of software systems, as well as for business modeling and other non-software systems (Object Management Group, 2001) [36]. The researcher used UML to document the software development process specifically during
analysis and design. Using UML the researcher was able to design different artifacts such as use case diagrams, sequence diagrams, domain model, collaboration diagrams and design class diagrams.

### 3.4 Rational Unified Process

The Researcher employed the Rational unified process (RUP) of system design and development (Craig, 2003 [10]; Jacobson et al, 1999 [20]; Kruchten, 2000 [22]) to achieve the second and third research objectives. Effort was spent on enforcing the two best practices of the RUP namely iterative development and feedback. Iterative development helps to avoid an attempt to identify and classify all the requirements before moving on with development through multiple iterations ensuring that the prototype grows incrementally over time. Feedback ensures that any changes that are encountered are not resisted but rather incorporated into the final system. The RUP was carried out in the four phases as namely inception, elaboration, construction and Transition

#### 3.4.1 Inception

This was an especially short phase, whereby the vision and business case of the project was identified. This was possible as a result of part of the data gathering process carried out. Vague estimates were made and plans written down for the first iteration to be carried. A few use cases were identified, a brief specification was also written in addition to the development of a glossary.

A high level candidate architecture and components were identified. MySQL was identified as the most suitable database for the system not only because of its being cheap as its open source but also due to its ability to be deployed on either Linux systems or Windows systems. It was also deemed necessary to develop a front end in Object oriented PHP using PEAR, HTML and Cascading Style sheets (CSS).

#### 3.4.2 Elaboration

During this phase most of the requirements where identified and written out in full. Further work was done on the use case model, specification and glossary. Domain modeling was also carried out during this phase, this was done by identifying and classifying the objects in the problem domain resulting in a domain model. The domain model is similar to a static information model of the domain entities. This was achieved by developing class diagrams.

The design model is a representation of the logical design using a set of diagrams. Work on the design model also began at this phase. The researcher thus developed object interaction diagrams of the system, package diagrams, and the data model (database schemas)
3.4.3 Construction

During this phase the researcher concentrated on refining the design model, more detailed sequence diagrams were developed and the database schema refined. The researcher also started working on the implementation model. The design model was then systematically transformed into executable code, object classes were implemented and databases fully developed.

3.4.4 Transition

The Researcher carried out extensive testing of the system during this phase of the RUP. Preparations were also made for the deployment of the system at the case study ART center. This involved identifying the appropriate hardware specification for running the system and designing the network structure for the system.

The system was installed at the reach out center to enable the users interact first hand with it. Validation is the process of determining whether the conceptual model is an accurate representation of the system under study (Williams, 2004) [63]. The system was also validated against the selected case study during this phase.

![Figure 3.1: Iterative and Incremental Development](image)

Adapted from Craig, Larman (2003) [10]
Chapter 4

IMPLEMENTATION AND PRESENTATION OF RESULTS

4.1 Area of Study

The aim of this study was to explore the application of a multi-dimensional architecture to adherence monitoring systems in antiretroviral therapy. This study required a case study ART center to be selected for the validation of the implemented system. Mbuya reach out HIV initiative was selected as a case study not only because of its long term experience in providing ART but also because of the large number of clients it has. Established in May 2001, the faith-based organization now caters for over 2000 patients. Reach-outs main mission is to curb the further spread of HIV infections by informing all patients about HIV/AIDS and to enable those who are already living with the virus, to live responsible, positive and dignified lives.

The ART center (Mbuya reach out) uses a paper based system to manage the patients who receive antiretroviral therapy from this center. Patient details like appointment, prescription, regimen and medical tests are recorded using pen and paper and stored in files, whereupon the patient is given a patient number corresponding to the file name for easier identification. At the patients next appointment, the patient file is retrieved when the patient identifies themselves using their patient number. At the end of the appointment any dispensation of the ARVs or tests that have been ordered and the patients next appointment dates are recorded. The researcher scheduled appointments and interviews with the director of the ART center, the pharmacist, two of the nurses, a receptionist and the lab technician. Observation of the center’s operation was also done and this yielded the results that are presented below.

4.2 Business Modeling

Domain object modeling was carried out during this phase. A domain model represents a web of interconnected objects where each object represents some meaningful individual. In developing the object model, classes were identified with their attributes, relations and connections. A domain model is indicated using a set of class diagrams, from the data gathering operations the researcher was able to identify the following objects in the problem domain. The table below indicates the classes identified and some of their attributes:
Table 4.1: Table 2: (Identified Classes and Attributes)

<table>
<thead>
<tr>
<th>Class</th>
<th>Child Classes</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Patient</td>
<td>i. name, ii. dateofbirth, iii. address, iv. Gender</td>
<td></td>
</tr>
<tr>
<td>2. Staff</td>
<td>Receptionist, Nurse, Pharmacist</td>
<td>i. name, ii. group, iii. dateofbirth</td>
</tr>
<tr>
<td>3. Drug</td>
<td>i. name, ii. category, iii. manuf.date</td>
<td></td>
</tr>
<tr>
<td>4. Prescription</td>
<td>i. date, ii. drugs</td>
<td></td>
</tr>
<tr>
<td>5. Appointment</td>
<td>i. date, ii. comment, iii. status</td>
<td></td>
</tr>
<tr>
<td>6. Supplier</td>
<td>i. name, ii. address</td>
<td></td>
</tr>
<tr>
<td>7. Regimen</td>
<td>i. name, ii. drugs</td>
<td></td>
</tr>
<tr>
<td>8. Test</td>
<td>i. name, ii. comment</td>
<td></td>
</tr>
</tbody>
</table>

From the above the researcher was able to develop the conceptual class diagram, which is as shown in the figure below:

Figure 4.1: Conceptual Class Diagram
4.3 Requirements

Using the different data gathering techniques the researcher was also able to develop comprehensive use cases for the system. This involved identifying the different actors and their respective goals, after which the detailed use cases were written.

The Actor-Goal list is as outlined below:

1. Actor: Nurse
   Goals:
   (a) Register Patient
   (b) Find Patient
   (c) Give Prescription
   (d) Check Adherence

2. Actor: Receptionist
   Goals:
   (a) Schedule Appointment
   (b) Cancel Appointment
   (c) Find Patient

3. Actor: Pharmacist
   Goals:
   (a) Add new Drugs
   (b) Add Stock
   (c) Dispense drugs
   (d) Check Adherence
   (e) Find patient

4. Actor: Lab technician
   Goals:
   (a) Capture test result
   (b) Find patient
The following are the detailed use cases:

**Use case UC1: Register Patient**

**Primary Actor:** Nurse

**Stakeholders and Interests**

-Nurse: Wants accurate, fast entry of patient details.

**Preconditions:** Nurse is identified and authenticated.

**Success Guarantee (Post Conditions):** Patient details are correctly saved, and patient Identification number generated and stored.

**Main Success Scenario:**

1. The Patient arrives at the nurses work station.

2. Patient provides the nurse with their personal details (name, age, and gender), medical history and social status (employed, marital status, number of children).

3. The Nurse enters the information given by the Patient into the System.

4. The system generates a Patient ID (a unique identification) for the new patient.

5. The Patient information is then saved into the system.

**Alternative flows:**

- At any time the System Fails:  

The detailed use cases show the primary actors, the preconditions, the success guarantees, main scenarios and finally the alternative flows. The Primary actors are principal actors that call upon the system to perform a particular service, the preconditions state what must always be true at the beginning of the use case, guarantees on the other hand give what is fulfilled at the end of a successful use case completion. The main scenario gives the set of steps in the execution of the use case and the alternative flows indicate all other scenarios both successful and unsuccessful.
Ensure that all sensitive transaction state and events can be recovered from the previous step in the scenario.

2a. The Patient does not have some all the information required by the Nurse.

4a. The System fails to generate a Patient id

**Frequency of occurrence:**

Could be nearly continuous

**Use case UC2 : Find Patient**

**Primary Actor:** Nurse, Receptionist, Pharmacist, Lab technician, Physician

**Stakeholders and Interests**

-Nurse: To locate a Patient and review their medical information
-Receptionist: To Locate a patient in order to schedule an appointment with the physician.
-Pharmacist: To locate a Patient in order to give them a prescription or review their prescription history.
-Lab technician: To locate a Patient and record the Patient’s test result.
-Physician: **Preconditions:** The Primary Actor is identified and authenticated by the system.

**Success Guarantee (Post Conditions):** The Patient is located and the Patient information in the system can be browsed and studied by the primary actor.

**Main Success Scenario:**

1. The Primary Actor enters the search criteria for the Patient. These search criteria can be the Patient ID, name, address, date of joining the reach out program etc.

2. The system displays the search results basing on the provided criteria.

3. The Primary Actor can then narrow the search if need be or choose the required patient from the list of results given.

4. The Patient information details can then be browsed as required by the primary actor.

**Alternative flows:**

2a. No search results are displayed

1. The Primary Actor is informed that the Patient details fitting the criteria given does not exist
2. The Primary Actor is given a choice of entering new search criteria.

4a. Patient exists in the system but their detailed information is not yet complete.

1. The Primary Actor is given an option of filling in the rest of the information.

**Frequency of occurrence:**

Used every time some specific patient information is required by one of the Primary Actors

**Use case UC3 : Give Prescription**

**Primary Actor:** Nurse, Physician, Pharmacist

**Stakeholders and Interests**

-Nurse: To assign the Patient to a correct regimen while preserving the future options
-Physician: To ensure that Patients have been assigned to correct regimens while observing future options.
-Pharmacist: To check that the pharmacy has drugs corresponding to the regimens being prescribed by the Primary Actors.

**Preconditions:** The Primary Actor and the Stakeholders have been identified and authenticated by the system.

**Success Guarantee (Post Conditions):** The Patient is assigned to a regimen and the Prescription information is stored permanently.

**Main Success Scenario:**

1. The Primary Actor enters the Patient ID and the system displays the corresponding Patient information.

2. The Primary Actor can then assign the Patient the appropriate regimen.

3. The prescription settings are then saved.

**Alternative flows:**

a* The System does not display the Patient information.

   1. The system signals error

   2. The Patient ID does not exist in the System. The Primary Actor is prompted to check the Patient ID entered.

   3. A new Patient ID can then be resubmitted to the System or, the Patient asked to register if they are new Patients.

2a. The Patient already has a Prescription assigned. This means that a change in Prescription is required.

   1. The Primary Actor then chooses the option to change the Patients Prescription.

   2. A new Prescription setting is then assigned to the Patient and the date of the change in prescription is noted.

3a. Prescription settings fail to be saved.

   1. The Primary Actor is notified of the failure in the operation.

   2. The Primary Actor is offered the chance to perform the operation one more time.

**Frequency of occurrence:**

Used for every new Patient before they receive the first batch of ARVs from the Pharmacy. This is also used for older Patients in the event of regimen change.

**Use case UC4:** Dispense Drugs

**Primary Actor:** Pharmacist

**Stakeholders and Interests**

- Pharmacist: Wants to efficiently dispense the correct amount of drugs to the Patient and also ensure that the patient has taken his/her previous supply of drugs correctly.

- Physician: Aims to ensure that the drugs in the pharmacy are being dispensed to the Patients as and when required and that there are no shortages

**Preconditions:** The Pharmacist is identified and authenticated.

**Success Guarantee (Post Conditions):** The Patient receives the drugs that they require and the details of dispensation are recorded and saved.

**Main Success Scenario:**

1. The Patient arrives at the pharmacy and gives the Pharmacist their Patient ID.
2. The Pharmacist enters the Patient ID into the system and the Patient ARV drug dispensation history is displayed.

3. The Pharmacist gives the Patient new drug supplies to last until the next patient appointment with a Physician (30 days).

4. The Pharmacist then enters the amount of drugs given to the Patient into the System.

**Alternative flows:**

2a. The Patient ID does not exist in the system
   1. The Pharmacist sends the Patient to the Nurse so the Patient can get registered into the system.

2b. The Patient Information does not match the Patient ID provided.
   1. The Pharmacist cross checks the Patient ID provided to ensure that it is correct.
   2. The Pharmacist can then enter the correct Patient ID.

**Frequency of occurrence:**
Used almost continually as patients come to the clinic.

**Use case UC5: Make Appointment**

**Primary Actor:** Receptionist

**Stakeholders and Interests**
- Receptionist: Ensure that Patient Medical appointments are scheduled and that the Patients Keep the Appointments.
- Physician, Nurse and Pharmacist: Checking that Patients are keeping their scheduled appointments especially since this helps in determining adherence to the medication.

**Preconditions:**
The Receptionist is identified and authenticated.
The Patient for whom an appointment is being scheduled must be present.

**Success Guarantee (Post Conditions):** The appointment is scheduled in the system and ready for tracking.

**Main Success Scenario:**

1. Patient arrives for an appointment and gives the Receptionist their Patient ID.

2. The Receptionist uses the Patient ID to retrieve the Patient Appointment information from the system.

3. The Receptionist orders the tasks (pending tests, review of patient condition) scheduled as per the particular appointment.

4. The Patient is then scheduled for consultation with a Nurse and the appointment date is set.

**Frequency of occurrence:**
Used almost continually as patients come to the clinic each must schedule their next appointment.

**Use case UC6: Add New Drug**

**Primary Actor:** Pharmacist

**Stakeholders and Interests**
-Pharmacist: Ensure that new drugs are recorded correctly into the system.

**Preconditions:**
The Pharmacist is identified and authenticated.

**Success Guarantee (Post Conditions):** The details of the new drug are permanently stored in the system.

**Main Success Scenario:**

1. The Pharmacist enters the name of the new drug into the system.
2. The System then prompts the Pharmacist for details about the new drug. Such as the drug Manufacturer, Suppliers, Prescription information,
3. Pharmacist inputs the details of the new drug into the system.

**Alternative Flows:**
2a. The name of the drug entered already exists in the system
   1. The system signals an error.
   2. The system informs the Pharmacist that the drug already exists in the system and prompts the Pharmacist to cancel the operation.
   3. The Pharmacist may also be prompted to enter a different drug name if this is a new drug being entered and not in the system

**Frequency of occurrence:**
Used almost continuously as patients come to the clinic each must schedule their next appointment.

**Use case UC7: Check Adherence**

**Primary Actor:** Nurse, Pharmacist, Physician

**Stakeholders and Interests**
- Nurse: Aims to ensure that the Patients are taking their medication as required.
- Pharmacist: Aims to ensure that the Patients are taking their medication and that the pharmacy has enough drugs to meet the Patient demands.
- Physician: Aims to ensure that Patients are taking their medication accordingly.

**Preconditions:**
The Primary Actor is identified and authenticated.
The Patient Exists in the System and has had at least one prior appointment at the Clinic.

**Success Guarantee (Post Conditions):** The primary actor will be able to tell to a degree how the Patient is adhering to the medication being given.

**Main Success Scenario:**

1. The Primary Actor enters the Patient ID or name of the Patient.
2. The system then displays the Patients drug dispensation and appointment history.
3. The Primary Actor can then counsel the Patient on why adherence is important and also try and find out why the Patient is not adhering to therapy.

4. If the Patient adherence is below a certain 80 Percent it is flagged and the Patient ID is noted amongst the defaulters

**Alternative Flows:**

2a. The Patient ID does not exist in the System.
   1. The system signals error
   2. The Primary Actor is informed that the Patient does not exist in the system.
   3. The System displays the option to register the new Patient into the System.

**Frequency of occurrence:**

Used almost continuously as patients come to the clinic each must schedule their next appointment.

**Use case UC8 : Add Stock**

**Primary Actor:** Pharmacist

**Stakeholders and Interests**

- Pharmacist: Wants to record all the new stock of drugs into the system to enable easier dispensation to Patients and hence ease in adherence monitoring.
- Physician: Aims to monitor the dispensation of drugs to the Patients, and ensure that enough drugs are bought in time to meet the Patient needs.
- Nurses: Need to know what drugs are in store so that what they prescribe to the clients are actually available.

**Preconditions:**

The Primary Actor is identified and authenticated

The drugs have actually been delivered to the Pharmacy from the suppliers and have been grouped by dosage. This could be one week dosage, 1 month or 2 month dosage et cetera.

**Success Guarantee (Post Conditions):** The System shall have a record of all the drugs that the Pharmacy has in store and ready for distribution to the Patients as and when needed.

**Main Success Scenario:**

1. The Pharmacist receives the set of drugs that are to be entered into the system from the suppliers.
2. The Pharmacist enters the Drug Id of the drug to be added to the stock.
3. The System displays the Information about the particular Drug.
4. The Pharmacist then inputs the amount of the particular drug that has been supplied by the supplier.
5. The date of delivery, manufacture and expiry of the stock in question is also entered by the Pharmacist into the system.
6. The Pharmacist the saves the information after confirming that it is indeed correct.
Alternative Flows:
3a. The Drug Id does not exist in the system.
   1. The system signals error
   2. The Pharmacist is informed that the Drug does not exist in the system.
   3. The System then provides the option of entering the new drug into the system.

Frequency of occurrence:
This is used each time new stock of drugs are delivered to the pharmacy.

Use case UC9: Record Test
Primary Actor: Lab Technician

Stakeholders and Interests
- Lab technician: Aims to ensure that Patients have undergone the tests ordered by the Nurses and Physicians and the test results noted.
- Nurses and Physicians: Need to view the results of the tests that they have ordered to assist in their diagnosis.

 Preconditions:
The Primary actors have been identified and authenticated
The Patient tests have been carried out and the results are ready to be input into the system.

Success Guarantee (Post Conditions): The Patient test results are saved into the system.

Main Success Scenario:
1. The Lab test results are performed and the results prepared by the lab technician.
2. The Lab technician enters the Patient Id into the system
3. The system displays Patient information corresponding to the entered Patient Id.
4. The Lab technician enters the test name, result and the date of the test for the particular patient.
5. The lab technician saves and exists the system.

Alternative Flows:
3a. The Patient Id does not exist in the system.
   1. The system signals error
   2. The System displays a warning that the Patient id provided does not exist in the system and should first be registered.
   3. The system offers the Lab technician a chance to input the proper patient identification.

Frequency of occurrence:
Used each time that a Patient takes a test ordered by the physician.
Briefly the actors, and use cases identified above can be summarized inform of a use case diagram. This is given below, with the users on the left indicating the primary actors and the users on the right indicating the secondary users.

![Use Case Diagram]

Figure 4.2: Use case Diagram
4.4 System Design

From the identified classes, the following collaboration diagram (Figure 4.3) was also generated, showing the inter-action between the different objects in a network format. This approach was used because it depicts the complex branching and interaction and concurrent behavior.

![Collaboration diagram](image)

Figure 4.3: Collaboration diagram

Sequence diagrams were also developed to show the interaction between different classes in the system in a horizontal manner.

Upon the user providing appropriate logins of passwords and usernames (Fig 4.4 Adherence Monitoring System Sequence Diagram I) the system is able to create a child class from the base class of staff. Depending on the logins
different base classes can be derived; the first case is a staff of the type receptionist, whose tasks include i. Searching for patients, ii. Scheduling appointments, and iii. viewing the scheduled appointments. Messages that reflect these tasks are then sent to an instance of the class Patient, whereupon the instance of the patient returns appropriate results to the object Receptionist::Staff.

If the staff logins specified depend on category 1, then a class of type Nurse is derived from the base class staff. Figure 4.4 above partially shows some of the messages that are exchanged between an instance of class Nurse and the an instance of class patient.

Instances of the base class Staff i.e derived class Nurse can also interact with instances of the class Regimen and instances of the class drug (Figure 4.5, below). In the first scenario, nurses are able to assign drugs to regimens, these form the 3 drugs making the combination for the HAART. The sequence diagram depicts the iteration used to generate the combination for the 3 ARV drugs forming the regimen. With the regimen established and the Nurse is thus able
to assign a given patient to a specific regimen. Changing a patient from one regimen to another can also be done with the same approach i.e establish the regimen that patient is to be changed to first, then secondly assign the patient to the new regimen.

An instance of a patient may also send a checkAdherence() message to itself; this message can be simply a request for an adherence check or more complex specifying dimensions including age, sex, number of children, number of spouses and so on, whereupon an adherence report can then be generated and sent as a message to the staff, in this case a Nurse.

A class Pharmacist is derived from the base class staff in the event that logins indicate category 3 (Fig 4.5). An instance of a Pharmacist may create a new drug incase the drug does not already exist in the system. The drugid is checked if it exist or not then if not a new drug is created ready to be dispensed to the patients, this is signaled by the an instance of the class drug returning the drugid to the pharmacist.
The pharmacist may then distribute the drugs to the patients by sending the message dispense with the parameters patientid and drugid. The patient may also send a message checkAdherence() to itself after which an adherence report can be sent to the pharmacist, thus enabling them to monitor the adherence of the different patients.

Logins reflecting category 4 signal the creation of the derived class Lab technician from the base class staff. These perform physician directed tests (medical tests) on patients, this process is achieved by requesting for the test id from the class Test, whereupon the specific test is carried out on the patient by sending the message giveTest() to an instance of the patient class and specifying the parameters patientid and the already established testid. The Patient class may also send a showTestResult (testid) message to itself, generate a test report and transmit this message to the staff, in this case the Lab technician (Fig. 4.6).

Figure 4.6: Adherence Monitoring System Sequence Diagram III

A physician is created on condition that the staff category is 5. Basing on the appointments with the different patients, he/she is in contact with the physician may opt to create and order for new tests to be performed by the lab technician,
hence the interaction with instances of the test class (Fig. 4.6). Dispensation of drugs to specific patients is also another task that may be done by the physician at this stage, indicated by message dispense(patientid, drugid). An instance of the patient class may also send a check adherence message to itself and specify a range of criteria. This criteria, depends on the different dimensions that may be in place, for instance age, sex, area of residence, and so on. An adherence report generated can then be sent to the physician.

4.5 Implementation of An Adherence Monitoring System

4.5.1 Backend

Having identified the classes and the use cases, the researcher went about developing the dimensional model and developing the user interface for the adherence monitoring system. The diagram below shows the dimensional model that the researcher came up with.

Figure 4.7: Adherence Monitoring System Dimensional Model
Table 4.2: Tables and attributes identified

<table>
<thead>
<tr>
<th>Table</th>
<th>Attributes</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Patient</td>
<td>i. pnumber, ii. Name iii. regimen iv. Gender</td>
<td>This table holds comprehensive patient information</td>
</tr>
<tr>
<td>2. Staff</td>
<td>i. name, ii. category , iii. password</td>
<td>Category indicates the access rights into the system</td>
</tr>
<tr>
<td>3. Drug</td>
<td>i. name, ii. category, iii. supplier</td>
<td>The type of ARV is reflected by the category e.g NNRTI</td>
</tr>
<tr>
<td>4. Regimen</td>
<td>i. Name, ii. description, iii.drugs</td>
<td>Each regimen is made up of at least 3 ARV drugs</td>
</tr>
<tr>
<td>5. Appointment</td>
<td>i. scheduledate, ii. patient, iii. status, iv. Comment</td>
<td>Used for tracking patient appointments to the center</td>
</tr>
<tr>
<td>6. Supplier</td>
<td>i. name, ii. address</td>
<td>Maintain information of the Suppliers of ARVs.</td>
</tr>
<tr>
<td>7. Stock</td>
<td>i. drug ii.Quantity iii. Supplier iv.</td>
<td></td>
</tr>
<tr>
<td>8. Adherence</td>
<td>i. patient ii.level iii. comment</td>
<td>Adherence Report Status shall be</td>
</tr>
<tr>
<td>9. drugsdispensed</td>
<td>i. patient ii.Quantity iii.date</td>
<td></td>
</tr>
<tr>
<td>10. Test</td>
<td>i. name, ii. comment</td>
<td>Record the tests that can be done on a patient. e.g TB</td>
</tr>
</tbody>
</table>

MySQL 5.0 a database management system was used to implement the dimensional model that had been developed during the design. This involved developing and running a number of SQL scripts (a full list is available in the Appendix A, the list also includes the sample data for the system) to generate the different tables in MySQL server. Some of the tables developed include patient, staff, drugs, tests, stock, Appointments, adherence, dispense, occupation, region, supplier and regimens. The table above indicate the tables developed and some of the fields in these tables. The regimen table indicates the different regimen options available and indicates the drugids of the drugs that form the HAART of that regimen. The occupation and region are elaborate dimensions of the patient, these tables enable the analysis of the patient treatment across not only the age and sex dimension but also across their occupation, salary scales, areas of residence to mention a few. Different dimensions to the patient can be added to the system as required by the treatment givers.

4.5.2 Front end

The front end for the system was developed in PHP 5.0 employing part of its object oriented capabilities. This was done together with some HTML and Javascript as the basic languages for development. The researcher also used Macromedia fireworks and flash to design some images and links that were embedded in the HTML and PHP code. For formatting purposes the researcher used cascading style sheets (CSS), these not only enable quick and smart downloads of requested pages but also provides for centralized changing of all the system interfaces. A full list of the codes for the different PHP scripts, HTML and CSS are included in the appendix.

Login and Security

Access into the system is restricted, any attempt to access the system displays a login page that requires the authorized users to provide a correct username and password that is matched against a pair of user name and password stored in the database table staff (An SQL script for its creation in MySQL can be found in the appendix A). This table also provides a category for the group that enables the system to detect whether the staff login corresponds to a receptionist,
nurse, pharmacist, lab technician or a physician. Depending on the group that they belong to then the access to the system functions is provided basing on this. Take an example of the receptionist, they would not be allowed access into the system in such a way as to enable editing of patient information; their specific tasks includes searching for patients, scheduling appointments and viewing the schedules appointments.

The figure below (fig. 4.8) shows a snap shot of the login page restricting security into the monitoring system, the second figure (fig. 4.9) displays the panel availed to the staff category receptionist. On login the system checks for the staff category provided and is thus able to create child classes from the staff class as depicted earlier in the System sequence diagrams (ref. fig4.4 through to fig4.6).

![Figure 4.8: Access Restriction: System login](image)

![Figure 4.9: System Interface for Receptionist](image)
Using PHP session variables, the interface for each staff in question also indicates the particular staff member that is logged into the system. This is evident in the screen mockup on figure 4.9 and the one on figure 4.10 which indicates the display in case it is a nurse that is logged into the system. The tasks that the nurse can perform are indicated on the left hand side of the interface; in this case carry out a patient search, register a patient, assign a regimen to a patient, change patient regimen and get a client report.

Figure 4.10: System Interface for a Nurse

4.6 Presentation of Results

To assign a patient to a regimen the Nurse is prompted to input the patients number which is unique; after which a regimen is selected from the drop down menu. This is done using the interface given in fig. 4.11 below. In the event that the Nurse or even the patient is not in position to recall the number, a system search of the patient can then be done.

When the results are displayed on the system, the nurse then has can view the detailed patient information, including full names, age, residence, status and so on. Different operations can then be carried out on the specific patient (ref to fig. 4.12, and fig. 4.13) for instance, assigning of regimen, change of regimen, and also performing an adherence check that then helps to generate the adherence monitoring report.
The list of patients above is generated simply by having the PHP script execute a query by selecting a number of patients from the patient table in the database. The operation for generating the detailed patient information involves the use of a PHP request variable that is used to determine the specific unique patient id. This is then in turn used to query the patient database for the corresponding patient information. The result is then displayed in a detailed interface as depicted in fig. 4.13. The specific technical implementation is included in the source code in appendix B.

The Staff can then assign the patient to a particular regimen or change the regimen that the patient was previously assigned to. The pharmacist can further monitor the levels of ARVs that are being used. This is done by analyzing the dispensation levels of the ARVs to the patients as detailed in the dispensation table in the database.
4.6.1 Adherence and ARV levels

The staff can also utilize the system to monitor the adherence levels and the ARV levels used by the patients. This information is generated by analyzing the patient across the adherence dimension, the appointment dimension and the drugs dispensed from the pharmacy. When a patient visits the ART center and schedules the next appointment, information such as the balance of ARVs the patient has, the appointments (both missed and those that were kept) are noted, and stored in the database. The adherence is then computed by: i. calculating the period (in days) between the present appointment and the previous appointment, ii. Calculating the number of ARVs dispensed to the patient, iii. Determining number of doses that the patient missed. From the above calculation the actual number of days the patient took the drugs is then established and this is divided by the overall time period between the appointments. This can be represented simply in the formula in figure 4.14 (Adherence monitoring formula).

Each time the adherence is calculated over the patients subsequent appointments to the ART centre and this is recorded in the database as a percentage. The patients overall adherence to the medication is then calculated as an average over the whole treatment period (This is shown in figure 4.14), any adherence of less than the required 95 percent is flagged
for notification by the health care givers. The system, replicates the formula by first requesting the user to provide a correct patient number, first name, last name or any one of the three. This is done using the interface in figure 4.15.

\[
Adherence_f(\%) = \left\{ \frac{\text{Number of Days Treatment Was taken}}{\text{Total Number of Days Over Which Adherence is being Monitored}} \right\}
\]

\[
Adherence_{\text{Overall}}(\%) = \left\{ \frac{\text{Adherence}_{T_1} + \text{Adherence}_{T_2} + \text{Adherence}_{T_2} + \ldots + \text{Adherence}_{T_N}}{N} \right\}
\]

Figure 4.14: Adherence Monitoring formula

The system then generates the patients performance, across dimensions, such as appointments, levels of ARV used and patient adherence to ART. Figure 4.16 shows one such report.

4.7 Testing

The researcher carried out testing concurrently with system development. Each of the developed classes was separately tested on implementation prior to its integration into the final system. This was done by identifying the methods
of each implemented class, invoking the method and verifying that the execution of the particular method achieved the objective of the class.

For instance the derived class nurse from the base class staff has the method registration, which is used to register new patients into the system, on performing a dry run of this method, the database was accessed and queried to ensure that the patient had actually been registered. This is depicted in the two tables below, the first table (Figure 4.17) shows a direct query into the database depicting the patients in the system before the method registration is invoked. For simplicity the table is just showing the last 5 patients registered in the database.
After the nurse registers a new patient into the system, a similar query on the database displays a table similar to the one below in the figure 4.18. This table now shows six patients as opposed to the previous table in figure 4.17 that showed only 5 patients. As in the previous case, only 6 of the last registered patients in the system have been displayed.

The new patient added to the system is MUHIMBISE LIVIA, during registration the system confirms that the patient has indeed been registered, by displaying the different parameters and other dimensions for the new patient. A typical example of one such screen is shown in the figure 4.19, this is generated by the method register method executed during the patient registration. The figure shows amongst other dimensions the patients date of birth, level of education, marital status, the number of children to mention a few.
During registration, the data entered is also checked for consistency for example: i). Checking that the patient’s date of birth is less than the current date ii). If this is not the case an error is generated, iii). Checking that if the patient dimension marital status is entered as never married then the entry for the number of spouses should be blank and other details such as the year of divorce should be blank as well. Figure 4.22 (Error Checking III-System Response) depict this clearly, showing the system response to wrong data entry. Another example is when a nurse attempts to assign a patient object to a new regimen, the system checks first whether the patient already exists in the system, if not then an error message is generated as depicted in figure 4.20(Error Checking I).
When registration is being done further checks are also made on the data prior to being submitted using javascript. For instance if the patient chooses 'Never Married' for their marital status then data such as the number of wives, divorce year and widow year are not displayed. In the event that other details such as the number of wives and divorce year are specified When the system is provided with inconsistent data during registration it responds by giving information similar to what is shown in the figure 4.22 (Error Checking-III).
Tracking of the dispensation of ARVs to patients was an objective of the research, dry runs of the nurse running dispensation methods were carried out. The database was then checked to ensure that ARVs had actually been deducted from the stock tables and linked to the specific patients who had visited the pharmacy. From this levels of ARVs used by the patients were also analyzed for consistency, this was then compared against the quantities of ARVs dispensed from the pharmacy. For instance the patient number K05/007 under the name AMONY ALICE generates the following report on figure 4.23 on levels of ARV, the number of appointments missed and the adherence over a period of time. The figure emphasis the ARV levels in form of tablets.
Table 4.3: Sample system logins

<table>
<thead>
<tr>
<th>Category</th>
<th>Group</th>
<th>Username</th>
<th>Password</th>
<th>Firstname</th>
<th>Lastname</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>RECEPTIONIST</td>
<td>leleku</td>
<td>123</td>
<td>Lean</td>
<td>Eleku</td>
</tr>
<tr>
<td>1</td>
<td>NURSE</td>
<td>mantondo</td>
<td>123</td>
<td>Nantondo</td>
<td>Rebeccah</td>
</tr>
<tr>
<td>2</td>
<td>PHARMACIST</td>
<td>pagwang</td>
<td>pass</td>
<td>Agwang</td>
<td>Pheobe</td>
</tr>
<tr>
<td>3</td>
<td>PHYSICIAN</td>
<td>gmargaret</td>
<td>open</td>
<td>Margaret</td>
<td>G</td>
</tr>
<tr>
<td>4</td>
<td>LABTECHNICAN</td>
<td>pmuwanga</td>
<td>123</td>
<td>Muwanga</td>
<td>Peter</td>
</tr>
<tr>
<td>5</td>
<td>SYSTEM</td>
<td>amsystem</td>
<td>2004ams</td>
<td>System</td>
<td>System</td>
</tr>
</tbody>
</table>

This was then concluded by doing component integration testing and system testing. The complete system was uploaded to an online web server and linked to the MySQL database the URL being http://ams.otinecharlesdaniel.com. Access logins for the different staff categories (0 through to 5 refer to Table 4.3) were created and access to the system tested.

### 4.8 Validation

Staff at Mbuya reach out were then invited to try using the system after being given the URL to the online system and the sample logins that had been created (refer to Table 4.3). Validation was carried out to establish whether the system generated is an accurate representation of the system studied and whether it was meeting the needs of the staff at the ART center. An online questionnaire (Figure 4.25) was developed where the staff could provide their feedback on using the system. A paper based version of the questionnaire is available in Appendix E.

![ART: Adherence Monitoring System](image)

Figure 4.24: Validation data entered through the electronic questionnaire
Ten different members of staff at the ART center filled in the questionnaire; these covered all the different staff categories in the system as evident in the sample data in figure 4.24 showing the different entries for the electronic questionnaire. The staff who responded to the questionnaire had been using the system for between 1 week and 4 weeks. Seventy percent of the staff who completed the electronic questionnaire agreed that the system was user friendly while the rest could not answer this because of their limited knowledge on the use of computers, but suggesting that from their interaction with colleagues the system is user friendly.

When asked whether the system eased their work 70 percent of the staff agreed that it did and 20 percent were undecided giving limited knowledge of ICT as the main reason as to why they couldn’t commit to the fact that the system did indeed ease their work. The Nurses, receptionists and lab technicians concurred that the system improved the speed and accuracy of retrieving patient information, with receptionist indicating that they were able to serve up to twice as many patients as before.

The pharmacists agreed that the system eased their work of dispensing ARVs especially the automatic calculation of the minimum drug dosage that each patient required until the next appointment basing on the appointment that was made with the pharmacist indicating that at this rate they could serve up to 20 more patients than before. The func-
tion of the system that the staff were most pleased with was the functionality for ARV levels followed by the check adherence function. Other system functionality that was considered very satisfying by the staff included the dispense function, registration function, appointment function and patient search.

All the staff members sighted a help tool as the main component that they immediately wanted added to the system, which the researcher endeavored to incorporate. One of the nurses also suggested an option of each user managing their accounts including updating and changing their passwords and logins.

There was consensus that the system bettered the previous paper based system in terms of the speed of access of the patient data when required, just by inputting the patient number or names. The directors were also pleased with the different dimensions of analysis of adherence with one director indicating that these different categories of information stimulated important questions regarding the reasons behind poor adherence under a given category. There was no ready response on the functionality of the system that the users most wanted changed immediately.

The Director agreed that the system can indeed be used to monitor adherence, the director also suggested that the researcher implement a help option for the system. This would enable the users of the system consult the help resource incase of any problems or difficulty when using the system. From the above information it was concluded that the system developed was sufficiently accurate for the purpose which it was developed, thereby validating the system.
Chapter 5

CONCLUSION

5.1 Introduction

This research set out to design and develop a multi-dimensional adherence monitoring system that improves the monitoring of patient adherence to ARVs. This chapter presents the recommendations, the areas for further research and the conclusion within the framework of this research and the objectives stated.

5.2 Recommendations

This research should be used as one of the components in synergizing the fight against HIV in Uganda and hopefully in Africa. This is for the most part because the system has been entirely developed in open source which makes it inexpensive for implementation where ART is being given. Uganda being a country with limited resources, cheap solutions to assist ART should be implemented. Reach out Mbuya should champion the use of the monitoring system in collaboration with the ministry of health by encouraging the use of the system amongst similar centers proving ARV treatment. Consequently a comprehensive information base will be developed; this should then be used to study patients undergoing antiretroviral therapy.

Training for staff directly interfacing with the system should also be done, to ensure that they maximize the functions of the system. This would involve tweaking the system to suit the staff for each individual ART center. Information about the system should be made available to others who may wish to study and modify the modules to suite their different needs in monitoring adherence not only to ARVs but to other treatment alternatives. This is important because adherence monitoring is not only a problem in ART but also an issue when treating other diseases, most notable is treatment to TB, which requires upto 100 percent adherence.

5.3 Areas for further Research

The scope of this research was ART treatment amongst adults excluding pediatrics treatment. This does not mean that adherence is not an issue amongst our young; in deed some may argue that it is more of a problem since these may not
quite grasp the importance this treatment, let alone recall that they have to intake the drugs. It is therefore imperative that alternatives of adherence checks be researched for this category of patients.

Patient records should be confidential and private; there are however inherent risks with having patient information in online systems. Consequently further research is also required in the area of security for the system; particularly in encryption systems that not only protects confidential patient information but also avoids slowing down the access to information in the system.

Limited literature on multi-dimensional health monitoring systems was a problem faced during this research. There is therefore need for more research in this area, especially research that yields solutions that are inexpensive, and easy to implement in limited resource settings like Uganda.
REFERENCES


38. PANOSAIDS


BIBLIOGRAPHY


Chapter 6

APPENDICES

6.1 Appendix A

SQL Scripts for AMS Database
Scripts
Scripts To be filled in last
6.2 Appendix B

System Source code
6.3 Appendix C

Adherence Reports for Selected Patients
These were generated during the system testing and validation
6.4 Appendix D

Proposal Approval letter from Faculty of computing and Information Technology.
6.5 Appendix E

Interview guide and Observation guide used during the data gathering task at reach out mbuya.
Validation Interview
6.6 Appendix F

Sample patient forms and documents from Reach out mbuya.
6.7 Appendix G

Application and Introduction letter to Reach out mbuya, requesting for permission to carry out study at the location.
Chapter 6

APPENDICES

6.1 Appendix A

SQL Scripts used to create database tables

CREATE TABLE `patient` (  
`patientid` int(11) NOT NULL auto_increment,  
`p_number` varchar(20) default NULL,  
`fname` varchar(30) NOT NULL default ",",  
`lname` varchar(30) NOT NULL default ",",  
`dob` year(4) NOT NULL default '0000',  
`telephone` varchar(15) default NULL,  
`sex` char(1) NOT NULL default ",",  
`mstatus` varchar(15) NOT NULL default ",",  
`occupation` int(11) NOT NULL default '0',  
`educ_level` varchar(30) NOT NULL default ",",  
`language1` varchar(30) NOT NULL default ",",  
`language2` varchar(30) default NULL,  
`residence` int(11) NOT NULL default '0',  
`no_wives` int(2) NOT NULL default '0',  
`no_wives_pos` int(2) default '0',  
`divorce_yr` year(4) NOT NULL default '0000',  
`widow_yr` year(4) NOT NULL default '0000',  
`no_kids` int(2) NOT NULL default '0',  
`doj` date NOT NULL default '0000-00-00',  
`status` char(1) NOT NULL default 'A',  
`d_date` date default NULL,  
`staffid` int(11) NOT NULL default '0',  
`regid` int(11) default NULL,  
PRIMARY KEY (`patientid`)  
) TYPE=MyISAM COMMENT='Holds Patient Information.' AUTO_INCREMENT=20;

CREATE TABLE `drug` (  
`drugid` int(11) NOT NULL auto_increment,  
`d_name` varchar(30) NOT NULL default ",",  
`d_brandname` varchar(30) default NULL,  
`category` varchar(30) default NULL,  
`supplierid` int(11) NOT NULL default '0',  
`staffid` int(11) NOT NULL default '0',  
PRIMARY KEY (`drugid`)  
) TYPE=MyISAM COMMENT='Holds the drugs in the pharmacy' AUTO_INCREMENT=38;
CREATE TABLE `adherence` (  `adherenceid` int(11) NOT NULL auto_increment,  `patientid` int(11) NOT NULL default '0',  `a_date` date NOT NULL default '0000-00-00',  `drug1` int(11) NOT NULL default '0',  `drug2` int(11) NOT NULL default '0',  `drug3` int(11) NOT NULL default '0',  `a_drug1` int(2) NOT NULL default '0',  `a_drug2` int(2) NOT NULL default '0',  `a_drug3` int(2) NOT NULL default '0',  PRIMARY KEY (`adherenceid`)  ) TYPE=MyISAM COMMENT='table to monitor the adherence of the patients' AUTO_INCREMENT=241 ;

CREATE TABLE `appointment` (  `appointmentid` int(11) NOT NULL auto_increment,  `scheduledate` date NOT NULL default '0000-00-00',  `a_date` date NOT NULL default '0000-00-00',  `patientid` int(11) NOT NULL default '0',  `staffid` int(11) NOT NULL default '0',  `a_comment` varchar(255) default NULL,  `a_status` char(1) default NULL,  PRIMARY KEY (`appointmentid`)  ) TYPE=MyISAM COMMENT='holds the appointment details' AUTO_INCREMENT=264 ;

CREATE TABLE `regimen` (  `regid` int(11) NOT NULL auto_increment,  `reg_name` varchar(10) NOT NULL default '',  `drug1` int(11) NOT NULL default '0',  `drug2` int(11) NOT NULL default '0',  `drug3` int(11) NOT NULL default '0',  PRIMARY KEY (`regid`)  ) TYPE=MyISAM COMMENT='Holds the different HAART regimens that are available to the' AUTO_INCREMENT=3;

CREATE TABLE `staff` (  `staffid` int(10) NOT NULL auto_increment,  `s_firstname` varchar(20) NOT NULL default 'Unavailable',  `s_lastname` varchar(20) NOT NULL default 'Unavailable',  `s_username` varchar(40) NOT NULL default '',  `s_password` varchar(40) NOT NULL default '',  `s_address` varchar(20) NOT NULL default '',  `s_dob` year(4) NOT NULL default '0000',  `s_tel` varchar(15) NOT NULL default '+256-',  `s_group` varchar(20) NOT NULL default '',  `category` int(1) NOT NULL default '0',  `s_dj` date NOT NULL default '0000-00-00',  PRIMARY KEY (`staffid`),  UNIQUE KEY `s_firstname` (`s_firstname`),  UNIQUE KEY `s_username` (`s_username`)
) TYPE=MyISAM COMMENT='this table records all the staff in the reach out' AUTO_INCREMENT=10 ;

CREATE TABLE `stock` (  
  `stockid` int(11) NOT NULL auto_increment,  
  `drugid` int(11) NOT NULL default '0',  
  `date` date NOT NULL default '0000-00-00',  
  `amount` int(8) NOT NULL default '0',  
  `s_manufacturedate` date NOT NULL default '0000-00-00',  
  `s_expirydate` date NOT NULL default '0000-00-00',  
  `s_comment` varchar(100) default NULL,  
  PRIMARY KEY (`stockid`),  
  KEY `drugid` (`drugid`) ) TYPE=MyISAM COMMENT='Holds the information on stock in the program' AUTO_INCREMENT=11 ;

CREATE TABLE `test` (  
  `testid` int(5) NOT NULL auto_increment,  
  `test_name` varchar(20) NOT NULL default '',  
  `test_comment` varchar(30) default NULL,  
  PRIMARY KEY (`testid`) ) TYPE=MyISAM COMMENT='holds the different tests' AUTO_INCREMENT=6 ;

CREATE TABLE `region` (  
  `regionid` int(11) NOT NULL auto_increment,  
  `village` varchar(25) NOT NULL default '',  
  `zone` varchar(25) default NULL,  
  `subcounty` varchar(25) default NULL,  
  `district` varchar(25) NOT NULL default '',  
  PRIMARY KEY (`regionid`) ) TYPE=MyISAM COMMENT='showing the different regions available' AUTO_INCREMENT=4 ;

Take note that a full list of all the tables and the sample data is available at http://ams.otinecharlesdaniel.com
6.2 Appendix B

System source code:

Database Connection (ams_connection)

```php
<? php
/*used to connect to the AMS database by all the classes that require this connection.
   It is stored in the folder Connection
   Code Written by OTINE CHARLES DANIEL
   Date 28.09.2006
*/
$hostname_ams = "mysql18.ixwebhosting.com";
$database_ams = "adminug_amsdb";
$username_ams = "adminug_amsroot";
$password_ams = "amsdb2007";
$ams = mysql_pconnect($hostname_ams, $username_ams, $password_ams) or
   trigger_error(mysql_error(),E_USER_ERROR);
?>
```

```php
<?php
/*Some Core classes*/

<?php
/*class definition for the left column*/
class leftcol{
  var $msg; // The Message to be displayed on the left column

  /*The Constructor */
  function leftcol($m)
  {
    $this->msg = $m;
  }

  function Display()
  {
    echo "<div id='leftcol'>
    <div class='b1s'><div class='b2s'><div class='tls'><div class='trs'><table width='100%' border='0' cellspacing='3' cellpadding='3'><tr class='nuggetheader'><td>|HOME|</td></tr><tr><td></td></tr><tr><td>AMS</td></tr><tr><td><a></a></td></tr></table></div></div></div></div>
    /*Display the Message that was assigned at the Object creation*/
    echo $this->msg;
    echo "</td></tr>

    echo "</td></tr><tr><td>AMS</td></tr><tr><td><a></a></td></tr></table></div></div></div></div>
} // end of the display
}```
var $title; //indicates the title at the top of the page
var $username; // The user currently logged on
var $note; // Any end note comments

function content($t,$e)
{
    $this->title = $t;
    $this->note = $e;
    $this->username = $_SESSION['MM_Username'];
}

function DisplaySearchPatient()
{
    echo "<div id='content'><div class='b1'><div class='b2'><div class='tl'><div class='tr'><table width='100%' border='0' cellspacing='5' class='datatable'><tr><td><div align='right'>WELCOME
&nbsp;&nbsp;</div></td></tr><tr><td>Complete the table below for the Details of the Patient that you are searching for:</td></tr><tr><td><div align='center'>
<form name='search' method='post' action='results.php?detail=s' style='color:blue'><table border='0' cellspacing='3' class='datatable' align='center'><tr class='nuggetbody'><td></td><td>Patient Number : </td> <td><label><input type='text' class='txt' name='p_number' id='p_number'></input></label></td></tr><tr></tr>
<tr class='nuggetbody'><td></td><td>First Name: </td> <td><label><input type='text' id='fname' name='fname'></input></label></td></tr>
<tr class='nuggetbody'><td></td><td>Last Name: </td> <td><label><input type='text' id='lname' name='lname' class='txt'></input></label></td></tr>
<tr class='nuggetbody'><td></td><td> </td> <td><input type='submit' id='search' class='btn' value='search'></input></td></tr>
<tr class='nuggetbody'><td></td><td><a href='results.php?detail=a'>View all Patients</a></td><td></td></tr></table></form>
</div></td></tr></table></div></div></div></div></div>"
    echo $this->username;
    echo "&nbsp;&nbsp;</div></td></tr><tr><td>Complete the table below for the Details of the Patient that you are searching for:
    echo "<form name='search' method='post' action='results.php?detail=s' style='color:blue'><table border='0' cellspacing='3' class='datatable' align='center'><tr class='nuggetbody'><td></td><td>Patient Number : </td> <td><label><input type='text' class='txt' name='p_number' id='p_number'></input></label></td></tr><tr></tr>
<tr class='nuggetbody'><td></td><td>First Name: </td> <td><label><input type='text' id='fname' name='fname'></input></label></td></tr>
<tr class='nuggetbody'><td></td><td>Last Name: </td> <td><label><input type='text' id='lname' name='lname' class='txt'></input></label></td></tr>
<tr class='nuggetbody'><td></td><td> </td> <td><input type='submit' id='search' class='btn' value='search'></input></td></tr>
<tr class='nuggetbody'><td></td><td><a href='results.php?detail=a'>View all Patients</a></td><td></td></tr></table></form>
";

class query {

    /*To perform Operations on queries*/

    var $name;
    var $RecordSet;
    var $Row;
    var $numRs;

    function query($q)
    {
        $this->name = $q;
    }
}
function check_result()
{
    $recS = mysql_query($this->name) or die (mysql_error());
    $numrows = mysql_num_rows($recS);
    $this->numRs;
    if ($numrows<1)
        return 0;
    else
        return 1;
}

function get_results ()
{
    $recSR = mysql_query($this->name) or die (mysql_error());
    $this->RecordSet = $recSR;
    $this->Row = mysql_fetch_array($this->RecordSet) ;
}

/*End of the Class*/

/*FUNCTIONS*/

/*This function calculates the difference in days between two dates*/

function dateDiff($dformat, $endDate, $beginDate)
{
    $date_parts1=explode($dformat, $beginDate);
    $date_parts2=explode($dformat, $endDate);
    $start_date=gregoriantojd($date_parts1[1], $date_parts1[2], $date_parts1[0]);
    $end_date=gregoriantojd($date_parts2[1], $date_parts2[2], $date_parts2[0]);
    return $end_date - $start_date;
}

/*STAFF CLASS*/
class staff {

    var $id,$s_firstname, $s_lastname, $s_username,$s_password,$s_address,$s_dob,$s_tel,$s_group, $s_doj, $category;
function getid()
{
    return $this->id;
}

//get the staff name
function getname()
{
    $name = $this->s_firstname . " ". $this->s_lastname;
    return $name;
}

function getusername()
{
    return $this->username;
}

function getpassword()
{
    return $this->getpassword;
}

function getcategory()
{
    return $this->category;
}

function getdob()
{
    return $this->dob;
}

//assign values

function givefirstname($name)
{
    if (!ereg ("^[A-Za-z']+$", $name) )
    {
        echo "<strong style='color:blue'>Error the name that you entered (".$name.") is incorrect!</strong>";
        exit();
    }else
    $this->s_firstname = $name;
}

function givelastname($name)
{
    if (!ereg ("^[A-Za-z']+$", $name) )
    {
        echo "<strong style='color:blue'>Error the name that you entered (".$name.") is incorrect!</strong>";
    }else
    $this->s_lastname = $name;
}
exit();
} else
{
$this->lastname = $name;
}
}

function giveusername($username)
{
if (!ereg ("^[A-Za-z']+$", $name) )
{
    echo "<strong style='color:blue'>Error the username that you entered (".$name.") is incorrect!</strong>";
    exit();
} else
{
    $this->username = $username;
}
}

function givepassword ($password)
{
    $this->password = $password;
}

function givecategory($category)
{
    $this->category = $category;
}

function giveaddress($address)
{
    $this->address = $address;
}

function givetel($tel)
{
if (!ereg ("^[0-9]{9}" , $tel) )
{
    echo "<strong style='color:blue'>Error the telephone number (".$tel.") is incorrect!</strong>";
    exit();
} else
{
    $this->tel = $tel;
}
}

function givegroup($group)
{
function givedob ($dob)
{
$this->s_dob = $dob;
}

function givedoj($dj)
{
$this->s_doj = $dj;
}

class webpage{

var $title = "AMS";

/*Displays the webpage*/

function webpage($t)
{
$this->title = $t ;
}

function Display()
{
  echo "<!DOCTYPE html PUBLIC "<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN" http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns='http://www.w3.org/1999/xhtml'><head>
    $this->DisplayTitle(); //Show Title
    $this->DisplayStyle(); //Display the Css Styles
    echo "</head><body>";
    $this -> DisplayContent(); //displays the content
    $this -> DisplayFooter(); //displays the footer, below the content
    echo "</body></html>";

  //End the Display
}

function DisplayTitle()
{
//starts the function to display the title
  echo "<$this->title">$this->title."</title><title>
} //end of function
function DisplayStyle(){
    //starts the function to display the cascading style sheets
    //Now I'll stop on the php so that I can use styles without the echo and all of that
?
    <link href="../Css/amslayout.css" rel="stylesheet" type="text/css">
    <style type="text/css">
    </style>
    <?
    } //ends the css styles

    function DisplayHeader(){
    //starts the function to display the part above the content.
    //start using html so I don't have to worry about the quotes with the echo
?
    <div id="layout">
    <div id="title">Aren't Classes Cool?</div>
    <div id="nav">
    <?
    } //end header

    function DisplayContent(){
    //display content

    //for page one, we are going to do a form
?
    </div>
    <div id="content">
    <form action="page1.php" method="POST">
    Pick 2 Numbers<br /><br />
    <select name="num1">
    <option name="num1" value="1">1</option>
    <option name="num1" value="2">2</option>
    <option name="num1" value="3">3</option>
    <option name="num1" value="4">4</option>
    </select>
    <select name="num2">
    <option name="num2" value="1">1</option>
    <option name="num2" value="2">2</option>
    <option name="num2" value="3">3</option>
    <option name="num2" value="4">4</option>
    </select>
    <input type="submit" value="Submit">
    </form>
    <?
    } //end content function

    function DisplayFooter(){
    //this displays the content after the content, the html stuff afterwards
<?php
/*REPORT, used to generate the Adherence levels and monitoring percentages
DONE BY Otine Charles Daniel*/

div id="leftcol">
<?php
$msg ="Patient Report<br><br><a href='physician.php'>Operations</a>";
$lc = new leftcol($msg);
$lc->Display();
?>
</div>
<div id="content">
<div class="b1">
<div class="b2">
<div class="tl">
<div class="tr">
<?php
mysql_select_db($database_ams,$ams) or die(mysql_error());
$choice = $_REQUEST['choice'];
switch ($choice)
{
    case 'a':
    ?>
    <form method="post" action="../physician/report.php?choice=i#adherence">
    <table width="100%" border="0" cellspacing="4" cellpadding="4">
<tr class="nuggetheader">
<td align="center">GENERATE A PATIENT REPORT (Fill in the form) </td>
</tr>
<tr class="nuggetbody">
<td align="right">Patient Number: </td>
<td width="8%">&nbsp;</td>
<td width="50%"><label>
<input name="p_number" type="text" id="p_number" max_length="8" /></label></td>
</tr>
<tr>
<td align="right">First Name: </td>
<td>&nbsp;</td>
<td><label>
<input name="fname" type="text" id="fname" /></label></td>
</tr>
</table>
</form>
<?php
?>
</div>
</div>
</div>
</div>
</div>
<tr><td><div align="right">Last Name: </div></td><td>&nbsp;</td><td><label><input name="lname" type="text" id="lname" /></label></td></tr>
<tr>&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;</tr>
<tr><td>&nbsp;</td><td>&nbsp;</td><td><input name="submit" type="submit" id="submit" value="Submit" /></td></tr>
<tr><td><div align="right">Detailed Adherence </div></td><td>&nbsp;</td><td><a href="report.php?choice=d">By Dimensions </a></td></tr>
</table></td></tr>
</table>
</form>
<?php
break;
case 'b':
?
<form method="post" action="/physician/report.php?choice=i#adherence">
<table width="100%" border="0" cellspacing="1" cellspacing="1" class="nugget">
<tr class="nuggetheader">
<td>GENERATE A PATIENT REPORT (Fill in the form) </td>
</tr>
<tr class="nuggetbody" width="100%" border="0" cellspacing="4" cellspacing="4">
<tr width="42%"><div align="right">Patient Number: </div></td>
<td width="8%">&nbsp;</td>
<td width="50%"><label><input name="p_number" type="text" id="p_number" maxlength="8" value="&lt;?php echo $_REQUEST['p_number'];?&gt;" /></label></td>
</tr>
<tr><td><div align="right">First Name: </div></td><td>&nbsp;</td><td><label><input name="fname" type="text" id="fname" /></label></td></tr>
<tr><td><div align="right">Last Name: </div></td>
<table width="100%" border="1" cellspacing="4"

<tr class="nuggetheader">
  <td><div align="center" class="style5">ERROR</div></td>
</tr>
<tr>
  <td class="nuggetbody"><div align="center">The Patient information Entered was not found in the System</div></td>
</tr>
<tr>
  <td class="nuggetbody"><div align="center"><a href="../physician/report.php?choice=b">Try Again</a></div></td>
</tr>
</table>

<?php
exit();

/*Correct and Patient has been found first is the patient details*/
$wqrow = mysql_fetch_assoc($RecordSetCP);

<?php
break;

case 'i':
$p_number = $_POST['p_number'];
$lname = strtoupper($_POST['lname']);
$fname = strtoupper($_POST['fname']);
//echo $p_number." \".$lname." \".$fname;
$queryCheckPatient = "SELECT * FROM patient WHERE ((patient.p_number = '$p_number') OR 
  (patient.lname = '$lname') OR (patient.fname = '$fname'))"
$RecordSetCP = mysql_query($queryCheckPatient) or die(mysql_error());
$num_rows = mysql_num_rows($RecordSetCP);
if (($num_rows) == 0) {
  ??
  <table width="100%" border="1" cellspacing="4" class="nugget">
    <tr class="nuggetheader">
      <td><div align="center" class="style5">ERROR</div></td>
    </tr>
    <tr>
      <td class="nuggetbody"><div align="center">The Patient information Entered was not found in the System</div></td>
    </tr>
    <tr>
      <td class="nuggetbody"><div align="center"><a href="/physician/report.php?choice=b">Try Again</a></div></td>
    </tr>
  </table>
  <br/>
  /*Correct and Patient has been found first is the patient details*/
  $row = mysql_fetch_assoc($RecordSetCP);
$patientid = $row['patientid'];
/* Appointments */
?>
<table width="100%" border="0" cellspacing="4" cellpadding="4" class="nugget">
<tr class="nuggetheader">
<td align="center">PATIENT DETAILED REPORT</td>
</tr>
<tr>
<td><table width="100%" border="0" cellspacing="4" cellpadding="4">
<tr class="nuggetbody">
<td width="33%"><strong>Full Name: </strong></td>
<td width="26%">$row['fname']. &nbsp;&nbsp; $row['lname'];</td>
<td width="41%"></td>
</tr>
<tr class="nuggetbody">
<td><strong>Patient Number: </strong></td>
<td>$row['p_number'];</td>
<td>&nbsp;</td>
</tr>
<tr class="nuggetbody">
<td><strong>Appointments:</strong></td>
<td>$qA = "SELECT COUNT(appointmentid) as allappts FROM appointment WHERE patientid='$patientid';"

  $rA = mysql_query($qA) or die(mysql_error());
  $rowA = mysql_fetch_assoc($rA);
  echo $rowA['allappts'];
  ?;</td>
<td>&nbsp;</td>
</tr>
<tr class="nuggetbody">
<td><strong>Missed Appointments: </strong></td>
<td>$qAM = "SELECT COUNT(appointmentid) as allappts FROM appointment WHERE (patientid='$patientid') AND a_status='N';"

  $rAM = mysql_query($qAM) or die(mysql_error());
  $rowAM = mysql_fetch_assoc($rAM);
  echo $rowAM['allappts'];
  ?;</td>
<td>&nbsp;</td>
</tr>
<tr class="nuggetbody">
<td><em>Comparison</em></td>
<td><div align="center">
  $gr = new HTMLGraph("150", "250", "Appointments");
  $gr->title->style = "text-decoration:underline";
  $plot = new HTMLGraph_BarPlot();
  $values = array($rowAM['allappts'], $rowA['allappts']);
  $labels = array("Missed", "All");
</div>
</td>
<td>&nbsp;</td>
</tr>
</table></td>
</tr>
</table>
$colors = array("red","green");
$plot->add($values,$labels,$colors);
$gr->add($plot);
$gr->footnote->caption = "Missed Appointments Vs All Appointments";
$gr->render();

</div></td>
</tr>
<tr class="nuggetbody">
<td><div align="right"><strong>ARV levels: </strong></div></td>
<td><?php
 /*Display Patients Duration of treatment*/
 $startdate = $row["doj"];  
 $enddate = date("Y-m-d");
 $df = '-';
 echo dateDiff($df, $enddate, $startdate)."nbsp;DAYS";
 ?></td>
</tr>
<tr class="nuggetbody">
<td><div align="right"><strong>Adherence: </strong></div></td>
<td><?php $qADHER = "SELECT AVG(a_drug1) adg1, AVG(a_drug2) adg2, AVG(a_drug3) adg3 FROM adherence WHERE patientid ="$patientid"";
 $RECSETADHER = mysql_query($qADHER) or die(mysql_error());
 $rowADHER = mysql_fetch_assoc($RECSETADHER);
 $gr = new HTMLGraph("200", "300", "Adherence to Regimen (%)");
 $gr->title->style = "text-decoration:underline";
 $plot = new HTMLGraph_BarPlot();
 $values = array($rowADHER['adg1'], $rowADHER['adg2'], $rowADHER['adg3']);
 $labels = array("TDF", "D4T 40", "BIVIR N");
 $colors = array("#CCFF67","#DD7F77","#FFBB87");
 $plot->add($values,$labels,$colors);
 $gr->add($plot);
 $gr->footnote->caption = "ARV Levels";
 $gr->render();
</td>
</tr>
if ($rowADHER['adg1']>95)  
{  
echo "<hr>";
  echo "<font color=green>PATIENT ADHERING ABOVE 95%</font>";
  echo "<hr>";
} else
{  
echo "<hr>";
  echo "<font color=red>PATIENT IS NOT ADHERING ABOVE 95%</font>";
  echo "<hr>";
}

</td></a>
</tr>
<tr class="nuggetbody">
<td>&nbsp;</td>
<td><em><a href="../physician/physician.php">Back</a></em></td>
<td>&nbsp;</td>
</tr>
</table></td>
</tr>
</table>

<?php
break;
case 'd':
/*Specify Adherence by Dimensions*/
?>
<form method="post" action="report.php?choice=c">
<table width="100%" border="1" cellpadding="4" cellspacing="4" class="nugget">
<tr class="nuggetheader">
<td><div align="center">DETAILED ADHERENCE BY DIMENSIONS</div></td>
</tr>
<tr class="nuggetbody">
<td><table width="100%" border="0" cellspacing="4" cellpadding="4">
<tr>
<td width="45%"><div align="right">Specify Dimension</div></td>
<td width="8%">&nbsp;</td>
<td width="47%"><label>
<select name="select">
<option value="5">Education</option>
<option value="2">Marital Status</option>
<option value="1">Occupation</option>
<option value="3">Region</option>
<option value="4">Sex</option>
</select>
</label></td>
</tr>
<tr>
<td>&nbsp;</td>
</tr>
</table>
</td>
</tr>
</table>
<table width="100%"> <tr class="nuggetheader"> <td><div align="center">ADHERENCE BY OCCUPATION</div></td> </tr> </table>
$queryDimMSTATUS = "SELECT AVG(a_drug1) a_drug1, AVG(a_drug2) a_drug2, AVG(a_drug3) a_drug3, mstatus FROM adherence, patient WHERE adherence.patientid = patient.patientid GROUP BY mstatus";
$RecordsetDimMSTATUS = mysql_query($queryDimMSTATUS) or die(mysql_error());
echo "<table class='nugget' width='100%'><tr class='nuggetheader'><td>ADHERENCE BY MARITAL STATUS</td></tr>

while ($rowDimMSTATUS = mysql_fetch_assoc($RecordsetDimMSTATUS))
{
    echo "<tr class='nuggetbody'><td><div align='center'>
$gr = new HTMLGraph("400", "300", "Adherence by Gender ($rowDimMSTATUS['mstatus'])");
$gr->title->style = "text-decoration:underline";
$plot = new HTMLGraph_BarPlot();
$values = array($rowDimMSTATUS['a_drug1'], $rowDimMSTATUS['a_drug2'], $rowDimMSTATUS['a_drug3']);
$labels = array("TDF", "D4T 40", "BIVIR N");
$colors = array("orange", "green", "grey");
$plot->add($values,$labels,$colors);
$gr->add($plot);
$gr->footnote->caption = "Adherence By Marital Status $rowDimMSTATUS['mstatus'];
$gr->render();
    echo "</div></td></tr>
    
    echo "</tr><td><a href='report.php?choice=d'>SELECT A DIFFERENT DIMENSION FOR COMPARISON</a></td></tr>
  
echo "</table>";
}

if ($dimension == 3) /*Show by region*/
{
    $queryDimREGION = "SELECT AVG(a_drug1) a_drug1, AVG(a_drug2) a_drug2, AVG(a_drug3) a_drug3, village FROM adherence, patient, region WHERE (adherence.patientid = patient.patientid) AND (patient.residence = region.regionid) GROUP BY village";
$RecordsetDimREGION = mysql_query($queryDimREGION) or die(mysql_error());
echo "<table class='nugget' width='100%'><tr class='nuggetheader'><td>ADHERENCE BY REGION</td></tr>

while ($rowDimREGION = mysql_fetch_assoc($RecordsetDimREGION))
{
    echo "<tr class='nuggetbody'><td><div align='center'>
$gr = new HTMLGraph("400", "300", "Adherence by REGION ($rowDimREGION['village'])");
$gr->title->style = "text-decoration:underline";
$plot = new HTMLGraph_BarPlot();
$values = array($rowDimREGION['a_drug1'], $rowDimREGION['a_drug2'], $rowDimREGION['a_drug3']);
$labels = array("TDF", "D4T 40", "BIVIR N");
$colors = array("orange", "green", "grey");
$plot->add($values,$labels,$colors);
$gr->add($plot);
$gr->footnote->caption = "Adherence By REGION $rowDimREGION['village']";
if ($dimension == 4) /*choice made is for adherence by sex*/
{
    $queryDimSEX = "SELECT AVG(a_drug1) a_drug1, AVG(a_drug2) a_drug2, AVG(a_drug3) a_drug3, sex FROM adherence, patient WHERE adherence.patientid = patient.patientid GROUP BY sex";
    $RecordsetDimSEX = mysql_query($queryDimSEX) or die(mysql_error);
    echo "<table class='nugget' width='100%'><tr class='nuggetheader'><td>ADHERENCE BY SEX</td></tr>
    
    while ($rowDimSEX = mysql_fetch_assoc($RecordsetDimSEX))
    {
        if ($rowDimSEX['sex'] == 'F') $gender = "FEMALES"; else $gender = "MALES";
        echo "<tr class='nuggetbody'><td><div align='center'>
            $gr = new HTMLGraph("400", "300", "Adherence by Gender ($gender)");
            $plot = new HTMLGraph_BarPlot();
            $values = array($rowDimSEX['a_drug1'], $rowDimSEX['a_drug2'],$rowDimSEX['a_drug3']);
            $labels = array("TDF", "D4T 40", "BIVIR N");
            $colors = array("orange","green","grey");
            $plot->add($values,$labels,$colors);
            $gr->add($plot);
            $gr->footnote->caption = "Adherence By Gender "$gender;
            $gr->render();
            echo "</div></td></tr>");
    }
    echo "<tr><td><a href='report.php?choice=d'>SELECT A DIFFERENT DIMENSION FOR COMPARISON</a></td></tr>
    
}
if ($dimension ==5) /*Adherence by Education Level*/
{
    $queryDimEDUC = "SELECT AVG( a_drug1 ) a_drug1, AVG( a_drug2 ) a_drug2, AVG( a_drug3 ) a_drug3, educ_level FROM adherence, patient, occupation WHERE ( adherence.patientid = patient.patientid ) GROUP BY educ_level";
    $RecordsetDimEDUC = mysql_query($queryDimEDUC) or die(mysql_error());
    echo "<table class='nugget' width='100%'><tr class='nuggetheader'><td>ADHERENCE BY EDUCATION LEVEL</td></tr>
    
    while ($rowDimEDUC = mysql_fetch_assoc($RecordsetDimEDUC))
    {
    
    }
}
```php
{ 
    echo "<tr class='nuggetbody'><td><div align='center'>";
    $gr = new HTMLGraph("400", "300", "Adherence by EDUCATION (".$rowDimEDUC['educ_level'].")");
    $gr->title->style = "text-decoration:underline";
    $plot = new HTMLGraph_BarPlot();
    $values = array($rowDimEDUC['a_drug1'], $rowDimEDUC['a_drug2'], $rowDimEDUC['a_drug3']);
    $labels = array("TDF", "D4T 40", "BIVIR N");
    $colors = array("orange","green","grey");
    $plot->add($values,$labels,$colors);
    $gr->add($plot);
    $gr->footnote->caption = "Adherence By EDUCATION LEVEL ".$rowDimEDUC['educ_level'];
    $gr->render();
    echo "</div></td></tr>";
}
```

```html
echo "<tr><td><a href='report.php?choice=d'>SELECT A DIFFERENT DIMENSION FOR COMPARISON</a></td></tr>
```

```html
echo "</table>"
```

```php
break;
default:
break;
}
?
?>
```
6.3 Appendix C

Adherence reports for selected patients at the center

Above depicts a report for an adhering patient.
Adherence report below indicates a patient who is not adhering:
Adherence by Gender:

The interface above shows adherence by gender (Males versus the females). It enables the director to compare how patients in the two different dimensions are adhering to therapy.

The interface that follows below indicates the adherence of patient by the employment dimension, showing the different jobs that the patients carry out.
During Validation an electronic questionnaire was designed and availed to the staff at the ART center to get feedback on the system. The questionnaire can be completed at the following digital address \texttt{http://ams.otinecharlesdaniel.com/validation.php}. The diagram below shows the interface for the questionnaire.
This shows the data for the staff that completed the electronic questionnaire online for the system validation process.

A paper based version of the questionnaire is available in Appendix E.
6.4 Appendix D

Proposal Approval letter from Faculty of Computing and IT signed by the head of department

MAKERERE UNIVERSITY
P. O. Box 7062 Kampala Uganda
E-mail: hodis@cit.mak.ac.ug
URL: http://www.cit.ac.ug

FACULTY OF COMPUTING AND INFORMATION TECHNOLOGY
DEPARTMENT OF INFORMATION SYSTEMS

31st August 2006

OTINE Charles Daniel,
Reg. No. 2004/HD18/1666U

Dear Mr. Otine,

RE: PROJECT PROPOSAL

The Final Project Proposal on “An Adherence Monitoring System in Antiretroviral Therapy” has been received and accepted by the Head of Department, Information Systems. The Head of Department has therefore recommended that you continue with your research under the supervision of Dr. Ddembe Williams.

By this letter, Dr. Ddembe Williams is hereby informed accordingly.

Yours sincerely,

[Signature]

Dr. Patrick Ogao
Ag Head of Department, Information Systems
6.5 Appendix E

The interview guide for the interviews conducted and the validation questionnaire.

**INTERVIEW GUIDE FOR STAFF AT MBUYA REACHOUT HIV INITIATIVE**  
*(Should last a maximum of 15 minutes)*

1. Greet the person being interviewed and introduce yourself.
2. For the record, could you please state your name and your job title at this ART center?
3. What is the purpose/ Mission of your organization?
4. Why do you feel you need a system?
5. What potential problems do you face on a daily basis?
6. What is your job description?
7. What kind of tasks do you perform on a typical day?
8. What kind of data/Information do you work with?
9. What types of reports do you see?
10. What kind of things do you need to keep track of?
11. What services do you provide to your patients?
12. Is there any sensitive information that should only be accessed by any staff?
13. Summarize the interview.
14. Thank the person being interviewed.
ADHERENCE MONITORING SYSTEM VALIDATION QUESTIONNAIRE

This questionnaire should be filled by staff who have used the adherence monitoring system.

1. DATE: __________________________ 2. STAFF CATEGORY: __________________________

3. LENGTH OF SYSTEM USE: __________________________

4. Is the system user friendly?:  YES: [ ]  NO: [ ]  UNDECIDED: [ ]  OTHER: [ ]
   (Tick the appropriate choice in 4 above)

5. Explain your choice in 4 above: (use the box below)
   __________________________

6. Using the system simplifies my work as compared to before. (Tick the appropriate choice below)
   YES: [ ]  NO: [ ]  UNDECIDED: [ ]  OTHER: [ ]

7. Explain your choice in 6 above:
   __________________________

8. Which function of the system are you most satisfied with?
   __________________________

9. What do you want added to the system?
   __________________________

10. Any other comment
    __________________________

An electronic copy of this questionnaire is available online at http://sms.otinecharlesdaniel.com/validation.php.
Thank you for taking the time to fill in this questionnaire.
### REACH OUT: COUNSELING FOLLOW-UP FORM

<table>
<thead>
<tr>
<th>Type of visit</th>
<th>A. Ongoing ✧</th>
<th>B. Adherence ✧</th>
<th>C. Crisis ✧</th>
<th>D. Status disclosure ✧</th>
<th>E. Social Problems ✧</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th># previous consultations client has had</th>
<th>This quarter ___</th>
<th>Last quarter ___</th>
<th>In the last year ___</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Counseling-affiliated attendances</th>
<th>This quarter</th>
<th>Last quarter</th>
<th>In the last year</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARV Education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARV Graduation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Couples support</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AA Group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CATTS training</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adolescent support</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Has marital status changed        |              |              |                 |
| Last sexual activity              |              |              |                 |
| Last condom use                   |              |              |                 |
| Family planning                   |              |              |                 |

| Client’s Treatment Category       | TB only ✧ | Prophylaxis only ✧ | ARVs ✧ | ARV and TB ✧ | PMTCT ✧ |

<table>
<thead>
<tr>
<th>Adherence Information</th>
<th>Satisfactory adherence ✧</th>
<th>Borderline adherence ✧</th>
<th>Unsatisfactory adherence ✧</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can explain treatment plan well</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can explain some aspects of plan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can’t explain most of plan well</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reasons, poor adherence</th>
<th>Patient-related issues ✧</th>
<th>Patient-related issues (2) ✧</th>
<th>Patient-related issues (3) ✧</th>
<th>Medication-related issues ✧</th>
<th>Medication-related issues (2) ✧</th>
<th>Medication-related issues (3) ✧</th>
</tr>
</thead>
</table>

|----------------------------------|-----------------|-------------------|-----------------------------|-----------------|------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|----------------------------------|
Summary, Discussion Notes

Behavioral/Intervention Plan

<table>
<thead>
<tr>
<th>Internal Referrals</th>
<th>External Referrals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CATTs □</td>
<td>Kiswa Health Center □</td>
</tr>
<tr>
<td>2. FFL □</td>
<td>JCRC □</td>
</tr>
<tr>
<td>3. OSF □</td>
<td>Mildmay □</td>
</tr>
<tr>
<td>4. BoL □</td>
<td>AIC □</td>
</tr>
<tr>
<td>5. Clinic □</td>
<td>Mulago PIDC □</td>
</tr>
<tr>
<td>6. Post-Test Club □</td>
<td>Mulago □</td>
</tr>
<tr>
<td>7. Home-based/palliative care □</td>
<td>Local Councils □</td>
</tr>
<tr>
<td>8. AA □</td>
<td>Naguru □</td>
</tr>
<tr>
<td>Treat. Impl Unit □</td>
<td></td>
</tr>
<tr>
<td>9. Legal Officer □</td>
<td></td>
</tr>
<tr>
<td>10. WFP □</td>
<td></td>
</tr>
<tr>
<td>11. Soc □</td>
<td></td>
</tr>
<tr>
<td>12. Other (specify)</td>
<td></td>
</tr>
</tbody>
</table>
**REACH OUT: Antiretroviral Regimen Treatment Form**

**Prescription:** Completed by _____________________________  Date: ______/____/____

**Start date:** ______/____/____

**Brand Name Combination**

<table>
<thead>
<tr>
<th>COMBIVIR</th>
<th>3TC 1X2</th>
<th>AZT 1X2</th>
<th>D4T 30 1X2</th>
<th>D4T 40 1X2</th>
<th>EFV 600 1X1</th>
<th>EFV 800 1X1</th>
<th>TDF 300 1x1</th>
<th>NVP 200 1X1 X 14 DAYS Then, 1X2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
<td>F</td>
<td>G</td>
<td>H</td>
<td></td>
</tr>
</tbody>
</table>

**REGIMEN:** [______]

**Generic:** [______]

<table>
<thead>
<tr>
<th>Name</th>
<th>MAXIVIR 30 TRIOMUNE 30</th>
<th>MAXIVIR 40 TRIOMUNE 40</th>
<th>BIVIR</th>
<th>BIVIR - N</th>
<th>Other (Specify)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
<td>G1</td>
<td>G2</td>
<td>G3</td>
<td>G4</td>
<td>G5</td>
</tr>
</tbody>
</table>

**Regimen Change**

<table>
<thead>
<tr>
<th>From Regimen</th>
<th>New Regimen: [______]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date: <strong><strong><strong>/</strong>__/</strong></strong></td>
<td>Completed by <strong><strong><strong>/</strong>__/</strong></strong></td>
</tr>
</tbody>
</table>

**Reason for STOP or CHANGE or DEFFERAL: [ ] Failing [ ] Toxicity (Explain below) [ ] Dying [ ] TB Reg.

(Circle one) [ ] Other (Specify) ______/____/____

**Probation Start Date: ______/____/____

**Any other notes:** ________________________________________________________________

**New Regimen Start Date: ______/____/____

**Regimen Change**

<table>
<thead>
<tr>
<th>From Regimen</th>
<th>New Regimen: [______]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date: <strong><strong><strong>/</strong>__/</strong></strong></td>
<td>Completed by <strong><strong><strong>/</strong>__/</strong></strong></td>
</tr>
</tbody>
</table>

**Reason for STOP or CHANGE or DEFFERAL: [ ] Failing [ ] Toxicity (Explain below) [ ] Dying [ ] TB Reg.

(Continue) [ ] Other (Specify) ______/____/____

**Probation Start Date: ______/____/____

**Any other notes:** ________________________________________________________________

**New Regimen Start Date: ______/____/____
**TB FOLLOW UP**

Name: **FAYISI NANTONGO**  
TB No.:  
Treatment unit: **REACH BUT ABUSA**  
Treatment course: #1 [ ] #2 [ ] #3 [ ]

<table>
<thead>
<tr>
<th>MONTH</th>
<th>Date</th>
<th>Results</th>
<th>Entry sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>20/06/04</td>
<td>++ +</td>
<td></td>
</tr>
<tr>
<td>2(3)</td>
<td>/ / /</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>/ / /</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>20/02/05</td>
<td>NEG</td>
<td></td>
</tr>
</tbody>
</table>

Months Completed: (Record code for regimen initial instead of ticking)

<table>
<thead>
<tr>
<th>Type of RX</th>
<th>Month 1</th>
<th>Month 2</th>
<th>Month 3</th>
<th>Month 4</th>
<th>Month 5</th>
<th>Month 6</th>
<th>Month 7</th>
<th>Month 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>New</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Relapse</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Failure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rx after default</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Entry sign

If Z, then circle reason:  
1. Death  
2. Left  
3. Transferred  
Date: __/__/__

Remarks:

..........................................................
..........................................................
..........................................................
..........................................................
..........................................................

**CATTS:** Christine Achola  
Date Assigned: 21/06/04

TB completion date: 28/02/05  
Date of TB Certificate of discharge: 20/03/05
VCT#: 1228

REACH OUT MBUYA PARISH HIV/AIDS INITIATIVES
COUNSELLING FORM

Date of first visit: 06/08/03 Sex[M/F] F

Name: (Religious Name) ANANYA ESTHER (Surname) ANYIRI

COUNSELLING: Counsellor’s # 12 Counselling Session: [ ] Individual 2 = Couple 3 = Group

Source of Information about Reach Out Project: [ ]

Reasons for Testing: [ ] AIDS Signs and symptoms [ ] Past HIV risk [ ] Current HIV risk
[ ] To get Married [ ] Lost Partner Co-Partner/Child/Parent [ ] Ill Partner/Co-Partner/Child/Parent
[ ] Others (Specify): ____________

Previously tested for HIV? [ ] Yes 2 = No Date of previous HIV test: ____________

Previous HIV result: [ ] Pos 2 = Neg 3 = Others (Specify): ____________ Test Center: ____________

If RO, VCT#: 1228 No. of Previous HIV Tests: ____________

Couples: Is he/she your Spouse? [ ] Yes 2 = No Duration lived together: _______ Years _______ Month

Name of Personal/Family Doctor/Medical services: DR. EMANSI KALENGLA CLINIC, KAMPALA

Name of person to contact in case of an Emergency: DR. EMANSI

CLIENT CONSENT FORM:

This is to certify that I came to this testing centre to be tested for HIV, and I hereby the centre to draw my blood and test.

I agree to confirm that the number on the blood sample is the same as that on my VCT form.

I accept that other tests may be done on my blood sample(s) to confirm my HIV status at the discretion of the testing centre/project, and that my blood sample may be stored anonymously for future testing(s).

I understand that taking an HIV test is purely voluntary. It is my choice to receive the results.

Name: ANANYA ESTHER Signature/Thumbprint: __________________________

Date: 06/08/03 Witnessed/Counseled by: FEES KATUMBA

LABORATORY:

Lab. Technician: DAVID WAMALE Attached Results: ____________

If couple, is couple discordant? [ ] Yes 2 = No Partner VCT#: 1: ______ 2: ______ 3: ______

RESULTS GIVING:

Results given? [ ] Yes 2 = No Client in denial? [ ] Yes 2 = No

Says has been faithful to partner, and no obvious symptoms

Repeat test needed? [ ] Yes 2 = No

Client’s other reactions/requests: __________________________________________

Agreed to join RO? [ ] Yes 2 = No

If Yes, program agreed to join: [ ] Couples’ Club [ ] AA Club [ ] Post Test Club [ ] Other specify ______

Entered By: __________________________ Date: ______/____/____
6.7 Appendix G

Application and introduction letter to Reach out Mbuya, requesting for permission to carry out study at the centre. Letter was addressed to the Director, Dr. Margaret.

The Director
Out Reach Program
Mbuya,

Dear Madam,

REF: MANAGEMENT INFORMATION SYSTEM FOR PATIENT MONITORING

I am a 25 year old graduate student at the Faculty of computing and Information Technology at Makerere University. I also work at Faculty of Technology Makerere University as a System administrator. Every graduate student is required to work on a project in their final year as a prerequisite for the award of the Masters degree. I am therefore required to identify possible areas for my final Projects and submit project proposals to the Project approval committee at the Faculty.

In light of this I have identified Out-reach Mbuya as a potential area for my research. This letter is therefore to kindly request your permission to enable me carry out a study of the Facility which will enable me determine exactly what you need with the aim of building a working Patient Management Information System for the facility.

Your kind consideration in this regard will be greatly appreciated.

Yours Sincerely,

Otine Charles Daniel