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DESIGN AND DEVELOPMENT OF A PROTOTYPE KNOWLEDGE BASE SYSTEM FOR HIV PRE-TEST COUNSELING

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN INFORMATION SCIENCE

BY
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Dedication

This thesis is dedicated to the three people who have taught me the meaning of endurance, detachment, and eternal love: Hee, Yike and Tiju.

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My most sincere gratitude goes to family, friends and instructors who have contributed in various ways towards the completion of this thesis. I run out of words when I attempt to thank each member of my wonderful family for the emotional and financial support, spiritual guidance, and love they have showered upon me, not only during the past two years, but in my entire life.

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
AIDS	Acquired Immunodeficiency Syndrome
ART	Antiretroviral therapy
ARV	Antiretrovirals
CDC	Center for Disease Control
ELISA	Enzyme-linked immunosorbent assay
HCP	Health Care Provider
HIV	Human Immunodeficiency Virus
KBS	knowledge-based systems
MOH	Ministry of Health
NGOs	Non-governmental Organizations
PLWHA	People living with HIV/AIDS
PMTCT	Prevention of Mother to Child Transmission
STD	Sexually Transmitted Diseases
STI	Sexually Transmitted Infections
TB	Tuberculosis
UNAIDS	Joint United Nations Programme on HIV/AIDS
VCE-AIDS	Voluntary Counseling Expert system on HIV/AIDS
VCT	Voluntary Counseling and Testing
WHO	World Health Organization

ABSTRACT

HIV/AIDS is a pandemic that has claimed and continues to threaten the lives of millions around the globe. In the effort to answer the question "what works?", Voluntary Counseling and Testing (VCT) has appeared as a potentially effective intervention to prevent transmission of HIV by changing sexual behavior, and also in enabling individuals to make informed decision on whether or not to be tested. At the present time, VCT is the focal preventive tool in Ethiopia that is also being used as a means of reducing the stigma associated with the disease. The continued efforts to encourage people to come forward for voluntary testing are, however, often hindered due to the stigma and taboo against open discussion about sex and sexually transmittable diseases.

In an attempt to address such problems, the objective of this thesis work is to look into the possibility of applying the expert system technology to VCT by developing a prototype expert system that can imitate the services of a VCT counselor. One of the methods used for achieving this goal is acquiring knowledge through unstructured interviews from five experts that are purposely selected from the domain (VCT counselors). The VCT centers were selected based on prior acquaintance with the VCT counselors, availability of transportation to and from the centres, availability of the counselors to give feed-back and close follow-up to the research work, attitude towards the new idea of developing an automated counselor, and so on. Secondary sources of knowledge, such as standard VCT guidelines from UN-WHO and Centre for Disease Control were also used to gather knowledge about the domain. This knowledge is then represented into a form that can be understood by a computer using production rules and mapping these rules into an expert system shell called Knowledge ProGold Version 3.0. The resulting prototype, Voluntary Counseling Expert System on HIV/AIDS (VCE-AIDS), includes a user-interface that serves to display questions, accept input from the user, and present the resulting decision of the system.

VCE-AIDS has been tested for performance on 15 users and achieved quite an encouraging result of about 90% accuracy (86.6%). VCE-AIDS is, however, limited to the pre-HIV-testing session of the counseling process and is recommended to be developed into a full-fledged system that includes post-HIV-test counseling.

CHAPTER ONE

1.1 INTRODUCTION

Ever since experiment started to substitute Human Faculties with Technology, expert systems have stood out as one of the most successful applications for Artificial Intelligence techniques (Cork Constraint Computation Centre, 2003). The discovery of expert systems closed that era in history when various services used to be rendered exclusively by highly specialized human experts. The study, planning and design of Expert Systems (ES) was refined over the years to give better functioning systems that combine the expertise of many qualified human specialists in a single "knowledge-base".

Expert Systems have proven successful in solving problems associated with shortage of human resources (experts) and other arenas of life (Russell and Norvig, 1995). In exploring the various areas of application, this study looks into the possibility of using the expert system technology to solve one of the burning issues of Ethiopia, i.e. HIV/AIDS. But first, the subsequent parts of this brief introduction attempt to answer questions related to what expert systems are, how such systems are actually designed, what and who is involved in the design process, where expert systems can be applied, and so on.

1.2 BACKGROUND TO THE PROBLEM

1.2.1. HIV/AIDS in Ethiopia

Unfortunately, Ethiopia is a nation that has suffered severely from and is still devastated by the HIV/AIDS pandemic. According to the 2004 report of the Earth Institute, the number of citizens currently living with the disease is estimated at 1.5 million (2.2%). Moreover, HIV prevalence among adults was 4.4% in 2003 (Ministry of Health, 2004).

It has been reported to have the 6th largest number of people living with HIV/AIDS in the world. One in every 25 people living with HIV/AIDS is an Ethiopian (UNAIDS, 2004). In recent years HIV/AIDS has been expected to reduce life expectancy by 4.6 years annually (The Earth Institute, 2004). According to the Fifth Report of AIDS in Ethiopia, HIV/AIDS is claiming an estimated toll of as many as 115,000 lives a year, and it is believed that this annual death toll could reach 200,000 deaths unless effective prevention and treatment strategies are made available. The epidemic has resulted in an estimated 539,000 orphans.

Among the infected population, the number of new AIDS cases in 2003 was estimated at more than 120,000 (Ministry of Health, 2004). Trend analysis of prevalence from 1982-2003 have shown an urban epidemic that rose sharply to a peak, and that has plateaued over the last 7 years; a steady rise of rural prevalence with consistent decrease in rate of progression; and a continuing gradual rise in national prevalence with signs of leveling at relatively low level (Ministry of Health, 2002).

Most HIV/AIDS infections in Ethiopia are due to unsafe sexual contacts. The direct causes for the fast progression of the epidemic in Ethiopia are unprotected sex and frequency of casual partners (National HIV/AIDS council, 2001). Despite the ongoing efforts to educate Ethiopians about the deadly disease, a large proportion of people living with HIV/AIDS in Ethiopia do not know their HIV status (The Earth Institute, 2004).

The social stigma attached to HIV/AIDS has placed additional strain on Ethiopia's ability to fight the disease, as people avoid diagnosis and treatment for fear of community rejection. Although there is no easy way to quantify the impact of discrimination on disease transmission or economic productivity in Ethiopia, it is strongly believed that stigma-

reduction through education is one of the critical elements of a coherent anti-AIDS campaign (The Earth Institute, 2004).

The situation of HIVAIDS in Ethiopia, as described above, naturally called for efforts to be made in order to fight the spread of the pandemic. One of the prevention strategies adopted by the government was that of Voluntary Counseling and Testing and is highlighted in the following section.

1.2.2. Voluntary HIV/AIDS counseling and testing

In the year 2003, Centers for Disease Control and Prevention (CDC) released a document called Advancing HIV Prevention: New Strategies for a Changing Epidemic. Among the four strategies contained therein, one of the priority areas is to expand routine, voluntary human immunodeficiency virus (HIV) testing.

It is, therefore, not surprising if prevention of HIV remains a critical priority for the Nation, especially considering the promising results of such efforts. According to Celum and Wang, "the most effective available strategies for prevention are HIV counseling and testing, behavioral interventions to become abstinent or to reduce risk-taking, and condoms." (Celum, Connie & Wang)

Voluntary Counseling and Testing (VCT) is an adolescent-focused service that should be given in a free-standing adolescent-friendly sites as opposed to government hospitals, which frequently deter youth from accessing services. For a long time, VCT services in Ethiopia have typically neglected adolescent needs for HIV prevention and reproductive health services.

1.3 STATEMENT OF THE PROBLEM

Concern regarding confidentiality, location of counseling centers, lack of awareness, bias towards open-discussion on the issue of HIV/AIDS, and many other factors have contributed heavily to the high prevalence of this deadly disease in such countries as Ethiopia. Despite the media coverage and hammering on stigma, a significant portion of the population still remains blind to the consequences of their sexual behaviors.

Perhaps the most useful tool so far in ensuring individual change of attitude towards the impact of HIV/AIDS in each person's life has been one-to-one consultations given by professionals on a voluntary basis.

From what statistics reveals, the number of people who actually gather up the courage to volunteer for testing have been minimal. This has been for many reasons - among which stands cultural pressure and stigma. In order to bring near the days when people will no longer feel any reservation to know their HIV status, they need to be assisted in helping them decide on what will be the right thing to do. It is, therefore, worthwhile to find alternative means that will help refine the current efforts that are underway towards preventing the spread of HIV/AIDS.

In light of the background given thus far, the main problem the research work attempts to solve is how to make counseling services available in such a way that those who wish to avoid the human-element in the process will have the opportunity to get this important counseling. With an answer to this question, the researcher hopes to provide the alternative to the traditional way of providing counseling before and after testing for HIV so that it'll be comfortable and particularly appealing for the youth.

1.3.1. Goals of Counseling

The counseling that occurs before and after HIV testing has three principal goals: (Celum et al.)

1. To provide counseling about risk reduction for HIV-negative persons,
2. To identify HIV-infected persons for clinical interventions, and
3. To provide counseling to HIV-positive persons about potential transmission.

With these primary goals at heart, the study aims at exploring the applicability of an expert system to voluntary counseling on HIV/AIDS.

1.4 JUSTIFICATION OF THE STUDY

There is no question as to how HIV/AIDS is widespread in such developing nations as Ethiopia. This makes the issue of finding all possible means that will help curb the spread quite important. And one of the effective means by which this deadly disease can be banned from ruining more lives is to advise people on the importance of knowing their HIV status. Once a person knows his/her status, they will know how to proceed into the future with caution, with or without the virus. This step is crucial as it can be the only means by which HIV/AIDS may be put under control in developing as in the developed nations.

The proposed expert system can be justified in terms of the benefits it produces. An expert system for providing consultation before and after HIV/AIDS testing can have a few obvious advantages; some of which are:

- It is much lower in costs compared with paying an expert or a team of specialists.
- Unlike a human expert, the expert system to be built will be available anytime the person to be consulted needs it.
- Especially in the Ethiopian context, the person under consultation will be more encouraged to have a free consultation with an expert system than a human counselor.

The researcher's personal experience in working with a consultant with the UNDP for assessing the impact of HIV/AIDS in Ethiopia proved the following:

- More often than not, people tend to resist receiving voluntary counseling for fear/shame of revealing/discussing their sexual history with another person, regardless of the fact that the person is a professional that is there to help them. This fact was supported by a series of field visits and consultations with HIV/AIDS counselors in selected civil service institutions in Addis Ababa, Jijiga and Assosa. (Ekpo, 2004)

- As it currently stands, only those people who have already decided to know about their HIV/AIDS status will receive Voluntary Counseling. However, the availability of an expert system outside health service institutions which people can "talk to" (without going to a human expert to receive consultation and even before deciding whether or not they wish to test) can increase the number of people who are well informed about pre and post testing for HIV/AIDS. This, in effect, is bound to encourage more percentage of the population to know about their HIV/AIDS status.

1.5 OBJECTIVES OF THE STUDY

The following objectives will enable the study to achieve the specified goals.

1.5.1 General Objective

The primary objective of the research is to design and develop a prototype knowledge-base for Voluntary HIV/AIDS Counseling with the overall aim of exploring the applicability of expert systems technology to the specific area of VCT.

1.5.2 Specific Objectives

A break down of the major objective will lead to the specific objectives that aim:

- To identify the challenges and opportunities associated with Voluntary HIV/AIDS Counseling in the Ethiopian context
- To identify the procedures, variables, and the domain knowledge used in VCT;
- To design a prototype for a knowledge based system that demonstrates the capacity of an expert system to give pre-counseling for voluntary HIV/AIDS testing.
- To test the reliability of the new system;
- To recommend suggestions for further work in the area.

1.6 SCOPE AND LIMITATION OF THE STUDY

The research work will go no further than developing a prototype expert system for providing HIV pretest counseling. The performance will be tested by experts involved in the design process and other experts who did not involve in the design process. It is, thus, clear that a few modifications and/or additions (by others that wish to pick up where the study has left off) will be required before the prototype can grow into a full-fledged counseling system.

1.7 METHODS

In order to fulfill the overall objective of the study and to also help understand the exact contribution of the work, a review of literature is necessary. Thus, previous works in the same area will be assessed in light of their inputs, design method, and other unique features. This method will clearly show what gap the research work will be able to fill or the new dimension it will explore.

Once that is established, the knowledge necessary to design an expert system would be acquired from the experts in the area, in this case Counselors for Voluntary HIV/AIDS Testing, through unstructured interview with five selected HIV/AIDS counselors in five different Health Care Institutions and/or HIV/AIDS affiliated institutions. The extensive effort, time and cost associated with reviewing and analyzing pre- and post-interview sessions has limited the number of counselors selected for the knowledge-acquisition process to a manageable size of five. Additional knowledge will also be acquired from general Voluntary Counseling and Testing (VCT) guidelines by institutions as the United Nations World Health Organization (WHO) and Centre for Disease Control (CDC).

The knowledge acquired through the interview method will then be represented in such a way that it can be understood by the computer through coding. This knowledge will later be used for decision-making by an expert system. Among the various formal methods that can be used for knowledge representation, the one that is applicable to the expert system shell (i.e. production rules) will be adopted as it fits the particular problem at hand.

The expert system shell used to develop the prototype is Knowledge Pro Gold version 3. The user interface that will allow interaction with the user is also developed using the expert system shell. The shell is selected based on availability, easy-to-learn design tools, error handler and debugging tools that allow easy tracing/fixing of design errors, comprehensive help system on each feature, and its readable code that will also make updating of the system a relatively manageable task. The Expert System shell also has an in-built backward chaining/reasoning capability, which is suitable for diagnostic problems. The shell is applied in numerous knowledge domains.

Consultation with experts, which is undertaken at each phase of the design process, ensures an accurate knowledge acquisition and representation. The measure of success of the project is the ability of the system to demonstrate the potential of giving a proper consultation to users.

1.8 APPLICATION OF RESULTS

The expert system to be developed is applicable for giving consultation to people who wish to be consulted about their HIV/AIDS status. The system can be used in clinics, hospitals, laboratories and health care centers that provide HIV/AIDS testing. It can also be used as a major tool for giving people the counseling necessary to make them aware about the importance of knowing their HIV status without them having to go to a medical institution where the testing is actually done. This can be very useful in terms of handing such vital information to people wherever they are.

The immediate beneficiaries of the study are students in higher institutions that have access to computers within the Universities or Colleges they attend, employees in civil service or private institutions with access to personal computers.

At a larger scale, the system can be modified to be available online so that anybody who has access to the Internet can benefit from having the option of getting an automated HIV/AIDS counseling both before and after testing.

1.9 ORGANIZATION OF THE THESIS

This research process can be categorized under the following three main phases:

Part I. Background

- Introduction
- Literature review
- HIV/AIDS Counseling

Part II. Design Phase

- Knowledge acquisition
- Knowledge representation

Part III. Development Phase

- Application of knowledge
- Performance (testing)

In the first phase relates to general facts in the design and development of expert systems, their historical unfolding, and their applicability and role in the field of medicine.

The second phase is focused on acquiring knowledge from domain experts in the field of HIV counseling. The chapters in this part provide an in-depth discussion of the various factors involved in HIV consultation and how this knowledge can be applied for developing an expert system including design issues related to building an expert system for HIV counseling. Knowledge representation is also performed in one of the chapters under this second part.

The third phase deals with application of knowledge and User Interface design using Knowledge Pro Gold version 3.0 software. Results of the prototype expert system's performance is also included in this portion.

Finally, the overall conclusions from the research and recommendations for future research in the area are given in the last chapter.

CHAPTER TWO
LITERATURE REVIEW

2.1. INTRODUCTION

This chapter attempts to briefly explore some of the major areas where expert systems have been applied in medical science in general, and in the area of HIV/AIDS in particular. Before addressing the two application areas, this chapter will briefly review the history, concepts and structure of Expert Systems in order to familiarize the reader with the meaning, importance, and role of expert systems.

2.1.1 An Overview of Expert Systems

Expert Systems are computer programs that are derived from a branch of computer science research called Artificial Intelligence (AI). AI's scientific goal is to understand intelligence by building computer programs that exhibit intelligent behavior. It is concerned with the concepts and methods of symbolic inference or reasoning by a computer, and how the knowledge used to make those inferences will be represented inside the machine (Engelmore & Feigenbaum, 1993).

The term intelligence covers many cognitive skills, including the ability to solve problems, learn, and understand language and AI addresses all of those. But most progress in AI has been made in the area of problem solving. AI programs that achieve expert-level competence in solving problems in task areas by bringing to bear a body of knowledge about specific tasks are called knowledge-based or expert systems. More often than not, the two terms, expert systems

(ES) and knowledge-based systems (KBS), are used synonymously. Taken together, they represent the most widespread type of AI application (Engelmore and Feigenbaum, 1993).

2.1.2 Terminology

In this Research, the terms knowledge-based systems is used in synonymous with expert systems. Some research works make a distinction between expert systems, which they see as systems that contain expert knowledge, whereas they see knowledge-based systems as systems that may contain any sort of knowledge. As there is no hard criterion to judge whether knowledge is expert knowledge or not, this distinction is not made here. According to Lucas, P. (2000) "....As knowledge is often derived from experts in a particular field, and early knowledge-based systems were actually developed in close collaboration with experts, the term expert system was the term used in the early days to refer to these [knowledge-based] systems."

Furthermore, Stefik, M. (1995) writes that "as the applications for the technology have broadened, the more general term knowledge system has become preferred by some people over expert system because it focuses attention on the knowledge that the systems carry, rather than on the question of whether or not such knowledge constitutes expertise."

Therefore, in this thesis work distinction will not be made between the two terms as the techniques used in knowledge-based systems and the ones used in building expert systems are identical (Lucas, P., 2000; Stefik, M. 1995). Hence, the terms 'expert system' and 'knowledge-based system' will be used interchangeably throughout the Thesis.

2.1.3 Definition

Numerous people have defined expert systems from various perspectives. Some of these definitions given to expert systems are quoted below:

"Expert systems are advanced computer programs that mimic the knowledge and reasoning capabilities of an expert in a particular discipline. Their creators strive to clone the expertise of one or several human specialists to develop a tool that can be used by the layman to solve difficult or ambiguous problems." (World Information Organization, 2005)

"An expert system is a computer program designed to simulate the problem-solving behavior of a human who is an expert in a narrow domain or discipline." (Expert Systems Development Group)

"They are programs of calculator that have the objective to provide useful advice to solve the problems, based on the knowledge of an "expert", that has remarkable experience in a definite field, and is therefore able to give correct answers." (Politecnico di Milano)

"[Expert Systems] simulate the process of human thinking by the application of knowledge and specific inferences." (Politecnico di Milano)

"In other words an experienced system is a real assistant; a guide that accompanies the user to a considered choice, through the use of simple logical prepositions (decision trees, tables of truth and questions to exclusion). In this way, the user, even though he doesn't have a good knowledge of the matter, will arrive in an independent way to the resolution of his own problem." (Politecnico di Milano)

The basic concepts the above definitions attempt to describe generally have a similar nature. Among the definitions given the one that will be used for the purpose of this thesis work is the interpretation by the Expert Systems Development Group, which views expert systems as "computer programs designed to simulate the problem-solving behavior of a human who is an

expert in a narrow domain or discipline". This definition is given preference due to its ability to convey the underlying function of expert systems in a simple and clear manner.

2.2. EARLY EXPERT SYSTEMS

The 1970s was a decade in the history of Artificial Intelligence when emphasis was placed on "Expert Systems" with the objective of matching or exceeding the performance of a human expert on tasks that are narrowly defined (Russell and Norvig, 1995). And with the success of the first knowledge-intensive system, DENDRAL - which was developed in the mid-1960s, knowledge representation became a convincing concept for the research community of Artificial Intelligence.

Following this pioneer work on expert systems, various expert systems were developed in diverse fields of study. As to Ignizio (1991), some of these early expert systems are:

- HEARSAY I and II: developed in 1969 and 1971 respectively at Carnegie-Mellon University in an attempt to demonstrate the possibility of a speech recognition system. The goal of the system was to have a computer understand spoken input. An important result of the HEARSAY project was the demonstration that an expert systems approach (i.e. the use of heuristics) was superior to what had been the conventional approach to speech recognition that relied on statistical tools (i.e. the analytical approach). At the completion of the project in 1975, the system had a vocabulary of about 1000 words and was able to correctly interpret spoken input roughly 75% of the time.

- GATES: an airline gate assignment and tracking expert system that was in use (in prototype form) at New York's JFK International Airport. The system was used to assist ground controllers in the assignment of gates to arriving and departing flights. GATES was developed using PROLOG, and implemented on a personal computer. As opposed to human experts who need between 10 and 15 hours to prepare an assignment, and as much

as an hour to modify the assignment each morning, GATES can create gate assignments in about 30 seconds.

- FXAA: is an expert system developed to provide assistant in foreign exchange auditing. During testing, the system demonstrated a productivity increase of 30-fold and provision for increasing the frequency of auditing from every 18 months to a monthly audit. FXAA is a rule-based expert system that has evidently made a major impact within Chemical Bank, which does $750 billion a year in foreign exchange trading.

- Jonathan's Wave: an expert in commodities trading that runs on two 286-based personal computers. The knowledge base is written in C while the interface engine is written in PROLOG. Incorporated in the program are the knowledge bases of several approaches to commodities trading and based upon their suggestions, and their past performance, the system determines the trades to be made. In this manner, the system somewhat acts as though it were using multiple experts to reach its conclusion.

- Insurance ExperTax: an expert in tax planning created to assist in the identification of tax planning and accrual issues. The system took more than one year to develop and consists of more than 3000 rules. Created in LISP and running on the IBM PC, the tool is an industry-specific enhancement to ExperTax, the expert system first developed in 1986 by Coopers and Lybrand.

- HESS: an expert scheduler for the petrochemical industry developed at the University of Houston in support of product scheduling at a major petrochemical firm's refinery. The knowledge base in HESS was developed via the acquisition of heuristic rules from two refinery product schedulers. The system was developed using the EXSYS expert system shell, and through a 12-month effort. HESS consists of about 400 production rules and runs on an IBM PC or compatible. The expert system accomplishes the scheduling task of

determining what product to produce at what time at a more consistent basis than a human scheduler.

- DustPro: an expert in mine safety developed by the US Bureau of Mines. This system replaces the limited number of human experts that assessed the air quality of mining operations. Based on the amount of coal and silica dust in the air, mining operations must be adjusted to ensure that safely requirements are satisfied. DustPro runs on a PC and takes about 15 minutes to reach a conclusion. The knowledge base consists of roughly 200 rules. By late 1988, the Bureau had delivered 200 copies of mining operations worldwide.
- TOP SECRET: an expert in security classifications that attempts to correctly classify a given document through the use of more than 100 classification guides to nuclear weapon security data within the Department of Energy. EXSYS was selected to perform the classification task and the knowledge base of this shell contains the rules from the classification guides that determine just how to classify a document (eg.g confidential, secret, or top secret).
- Codecheck: an expert in computer program assessment. The package is a rule-based expert system that checks C source code for such things as complexity, formatting, and adherence to standards. Codecheck was designed to evaluate the protability of the source code by comparing it with the numerous standards for C programs and identify any code that will not port between DOS, OS/2, UNIX, VMS and Macintosh.
- The expert system technology has even permeated the fast food market into such companies as Wendy's, McDonalds, Pizza Hut, Burger King and Kentucky Fried Chicken. Such systems served to reduce inventory, speed up service, and even act as training assistants.

It did not take long for the application of expert systems to gain popularity in the field of medicine. Within a decade from the development of DENDRAL, such systems as MYCIN,

INTERNIST, PUFF, and QMR were applied in such medical problems as blood infection, internal medicine, pulmonary disorders and medical diagnosis respectively.

2.3. AREAS OF APPLICATION

Expert systems, as problem solving and decision-making mechanisms, have been used in many disciplines such as medicine, mathematics, engineering, geology, computer science, business, law, defense and education. The nature of problems they set out to solve are different in each area, thus making their application unique within the domain they are applied to. Each problem type, therefore, calls for a different problem solving technique.

Thus, although expert systems are applicable to most areas, their focus is on the problem type rather than on the domain/field of study itself. The domain categories for expert systems are: interpretation (e.g. weather data), prediction (e.g. weather forecast), diagnosis, design, planning, debugging and repair, instruction (e.g. tutoring), surveillance (e.g. discovery of discrepancies), and control (e.g. correction of discrepancies) (Eriksson, Henrik).

2.3.1 Expert Systems in Medicine

As mentioned so far, expert systems are one of the most widely applied areas of Artificial Intelligence that have contributed a great deal to various fields of study. Medicine is one of these diverse fields that, from the earliest days of expert systems, enjoyed the benefits of such technologies for solving complex problems and making medical decisions. Although other useful problem areas were emerging which lend themselves well to expert systems, medicine is still a popular research area in expert system application.

The technology of expert systems in the field of medicine came to the front scene through efforts that extended for decades. The delay in registering the desired results can be attributed to the "unrealistic expectations based on a fundamental misconception of their applications to clinical medicine" (Easy Diagnosis). Academically oriented researchers in the area held the opinion that diagnosis, especially for rarely seen disorders, was the central problem in medicine.

As documented in the time-honored Clinicopathological Case Conference, "common conditions are overwhelmingly common; exotic conditions are overwhelmingly rare, and many clinical presentations cannot be given an official diagnostic ICD* code and therefore are not nameable or classifiable. Thus, they persist in being undiagnosable ("unverifiable") by classic imaging or laboratory criteria" (Easy Diagnosis).

Later systems, such as Internist I, then evolved to address obscure as well as common diagnoses. But there were fewer attempts to handle symptom presentation (such as headache, nonspecific chest, back, abdominal pain, and so on). The failure to deal with the probability of disease given a presentation "was a direct outgrowth of the paucity of quantitative clinical knowledge and the plethora of laboratory data" (Easy Diagnosis).

Towards the end of 20th century, the focus of expert systems had already started undergoing a shift to the medical sciences. A survey conducted by Waterman in the year 1986 to study the application areas of expert systems revealed that the majority of expert systems built in the 1980's were in the field of medicine. Later in 1993, Durkin suggested that expert systems in medicine still accounted for about 12% of those were under development in the early 90s (Darlington).

* International Classification of Diseases of the World Health Organization

Some expert systems are built to assist non-experts in accomplishing certain tasks or making decisions as an expert. But most medical expert systems are designed to assist physicians in making complex decisions rather than for direct use by patients. According to a report presented at the Congress on Medical Informatics in San Francisco in Spring of 1989 (cited in Frenster, 1989), "medical expert systems have evolved to provide physicians with both structured questions and structured responses within medical domains of specialized knowledge or experience".

By incorporating the advice of more than one medical expert, the most accurate conclusion can be drawn from the answers provided by the physician to a set of optimal questions embodied in the program.

One of the earliest expert systems in medical science is the INTERNIST/ CADUCEUS. This system is an expert in Internal Medicine that started in 1970s under the name INTERNIST and later continued to be known as CADUCEUS (Ignizio, 1991). This expert system remained a viable project for a significantly extended period despite its ambitious objective to "perform a diagnosis of the majority of diseases associated with the field of internal medicine" (Ignizio, 1991). The main problem faced by this system was "combinatorial explosiveness", which is associated with the task of finding all possible combination of disease that might be present in a patient (estimated to be in the order of 10 to the 40^{th} power) (Ignizio, 1991).

Perhaps the most widely known medical expert system to date is MYCIN. Despite the fact that it has never been put to practice, MYCIN has "served to substantially influence much of the subsequent work in the construction and implementation of expert systems" (Ignizio, 1991, p. 53). MYCIN was developed at the University of Stanford in the mid-1970s as an exclusive research effort that can illustrate how expert systems can be applied to real-world problems.

The proposed role for MYCIN was providing assistance to physicians in the diagnosis and treatment of meningitis and bacteremia infections. The system had about 450 rules and performed "as well as some experts, and considerably better than junior doctors" (Russell & Norvig, 1995, p.23). Apart from the fact that MYCIN was designed to focus on specific diseases, it somehow has a comparison in its objective to INTERNIST/ CADUCEUS.

The considerably smaller knowledge base of MYCIN contains "heuristic rules used by physicians in the identification of certain infections" (Ignizio, 1991, p. 53). By removing this specific knowledge-base, EMYCIN (empty MYCIN) was acquired to enable the collection and insertion of a knowledge-base from another domain to give a new expert system (Russell & Norvig, 1995). This *plug-in* concept is what is later termed as expert system shell.

Another notable example in medical expert systems is PUFF, which was developed in 1979 using the EMYCIN shell. This system was designed to diagnose the presence as well as severity of lung disease. PUFF accomplishes this task by "interpreting measurements from respiratory tests administered in a pulmonary function laboratory" (Darlington). The data involved in the process of interpretation include test results such as total lung capacity, and patient history.

Brain Tumors Diagnostic System (BTDS) is yet another expert system that provides assistance to a physician in the diagnosis of brain tumors. The causes of brain tumors were judged by the BTDS based on computed pictures. In addition to the expert system component, BTDS also has a learning system where instances from known data are used to induce rules that represent the knowledge in the domain (Darlington).

Quick Medical Record, QMR, is a Medical Diagnostic Expert System developed using the huge knowledge base that was originally constructed for INTERNIST. QMR was designed "to assist

physicians in the diagnosis of an illness based upon the patient's symptoms, examination findings, and laboratory tests" (Ignizio, 1991, P. 56). Containing over four thousand possible manifestations of diseases, the performance of QMR is said to be as good as a practicing physician (Ignizio, 1991)

The Breast Cancer Diagnosis Application is an expert system developed in Japan for early detection of breast cancer. This expert system was designed to undertake a dialogue with women who are concerned about breast cancer. The conversation involves two parts: listening and explaining. In the first part, the system "listens" to the woman's symptoms regarding the breast and then gives the appropriate advice.

In the other part, an explanation is given regarding breast cancer and how to detect it in its early stages. So, the system presents its conclusions and suggests course of action that the woman should take after receiving information from the woman about her symptoms (Darlington).

The bulk of Artificial Intelligence and/or Expert System literature provides many more clinical tasks to which expert systems have been applied such as alerts and reminders, diagnostic assistance, therapy critiquing and planning, prescribing decision support systems, information retrieval, image recognition and interpretation, etc. The examples in the foregoing sections from the general area of medicine were meant to serve as a prelude to the review of expert system application to works that specifically relate to HIV/AIDS.

2.4. Concepts of an expert system

2.4.1 Characteristics

From the above definitions and more, we can generally identify some behaviors that characterize expert systems (Darlington):

- They simulate the process of human thinking through the application of rules inferred from the behavior of real experts;
- They must be able to explain their own behavior and justify their own actions by exhibiting explanations on reached conclusions;
- They (usually) separate domain specific knowledge from more general purpose reasoning and representation techniques.
- They remain limited to narrow problem domains such as troubleshooting malfunctioning equipment or medical image interpretation.

2.4.2 Types of Expert Systems

An expert system can be one of the following five types: rule based, object oriented, logic based, induction based, and hybrid systems (Eriksson).

A rule-based expert system is an expert system that encodes its knowledge in the form of "IF...THEN" rules, alternatively referred to as production rules. A typical rule assumes the form IF condition/premises, THEN action/conclusion. In some instances, this is extended to include IF-THEN-ELSE rules. In a rule premise, we are testing (or comparing) the value in the statement with any value provided. In the conclusion, we are assigning a value to an attribute. Rule-based expert systems were applied to such early systems as MYCIN and many others that followed. As can be seen in many expert system related literature, expert systems designed for the area of diagnosis in medicine have mostly employed the "IF....THEN" technique. The designing of expert systems using rule-bases is particularly appealing for expert systems that involve dialogue between the user and the system. Because of these proven advantages, the rules in the prototype knowledge-base of this Thesis work are also designed using the rule-based system.

In object-oriented expert systems, the fundamental concept is the "object," which combines data structure and behavior in a single component. In turn, each object is characterized by its state and its actions, which are the attributes and values of the object respectively. Actions are then the operations that the object is capable of executing. Each object is also a member of a class. Libraries of class definitions are an important asset, and are the basis for the reusability resulting from the object-oriented approach (Ignizio, 1991).

Induction based expert systems use Rule induction (RI), which is one of the fastest means of extracting rule-based knowledge from previous cases. In this approach, an inductive learning algorithm is responsible for reasoning and consistency checking.

Logic based expert systems use simple true/false logic to evaluate data, or at a more sophisticated level, they are capable of performing at least some evaluation taking into account real-world uncertainties, using such methods as fuzzy logic. Fuzzy logic is an extension of Boolean logic dealing with the concept of partial truth. Whereas classical logic holds that everything (statements) can be expressed in binary terms (0 or 1, black or white, yes or no), fuzzy logic replaces boolean truth values with degrees of truth. According to the Wikipedia Encyclopedia (cite in Fuzzy logic, 2006), these statement representations are in fact nearer of real-life human problems and statements, as truth and results are most of the time, partial (not binary) and/or imprecise - as in inaccurate, blurred, fuzzy.

Hybrid expert systems employ a decision-analysis tool formed through the judicious combination of an expert system and some other methodology. Decision making is thus performed through the combination of two, or more, different classes of decision-analysis tools. An example can be a decision tool formed through the combination of an expert system and a

linear programming algorithm. The term "Hybrid" is sometimes reserved for expert systems that use more than one form of knowledge representation such as both rules and frames.

In general terms, however, expert systems can be divided into two big branches based on the problem to be addressed (World Information Organization, 2005):

- Those classical, based on certain logic also said "deterministic";
- Those that concern the treatment of the uncertainty of the data of input: for example the Fuzzy logic and the Bayesian nets.

The deterministic expert systems have the advantage of providing the user a single solution that satisfies all the applications; and that of avoiding attributing different weights to questions and answers. Their disadvantage lies in that they don't know how to face the possible uncertainty of the user, refusing the opportunity when one feels like providing more than one answer. Rule-based expert systems cannot handle unanticipated events, as every condition that may be encountered must be described by a rule (World Information Organization, 2005).

2.5. NEED FOR EMPLOYING EXPERT SYSTEMS

Expert systems have remained attractive and in-demand because of the many advantages they provide in areas where they are applied effectively. Ignizio (1991, p. 9) noted, the use of expert systems becomes justifiable in terms of their:

- Availability: unlike a human expert, expert systems are instantly available
- Access: direct and instantaneous access to the necessary databases
- Awareness: an expert system will not overlook any critical event it has been assigned
- Consistency: unswayed by emotional arguments

- Loyalty: makes its decision with regard to the goals of a firm rather than personal promotions, and
- Asset value: repository for the storage of the knowledge of experts.
- Other needs:
  - To preserve knowledge that might be lost through the retirement, resignation or death of a company's acknowledged expert in any field; and
  - To "clone" an expert mechanically so his/her knowledge can be disseminated.

Expert systems also prove their importance in situations where experts in a particular area are scarce, expensive, and unavailable, and/or for assisting in solving complex problems.

2.6. DESIGN OF EXPERT SYSTEMS

2.6.1 Expert System Architecture

In order to build any expert system, one requires a user interface, database, knowledge base and an inference mechanism. The media through which the user interacts with the expert system is what is known as a user interface. The knowledge base generally stores the knowledge acquired from an expert in the form of a set of IF-THEN rules (in the case of a rule-based expert system) or other format.

The mechanism used to "reason with both the expert knowledge (extracted from our friendly expert) and data specific to the particular problem being solved" (Cawsey, A., 1994) is what is known as an *inference engine*. The *database* contains case specific data provided by the user and/or partial conclusions (along with certainty measures) based on this data. In addition to these, expert systems also have an explanation *subsystem*, which allows the program to explain its reasoning to the user, and a *knowledge base editor*, which helps the expert or knowledge engineer to easily update and check the knowledge base.

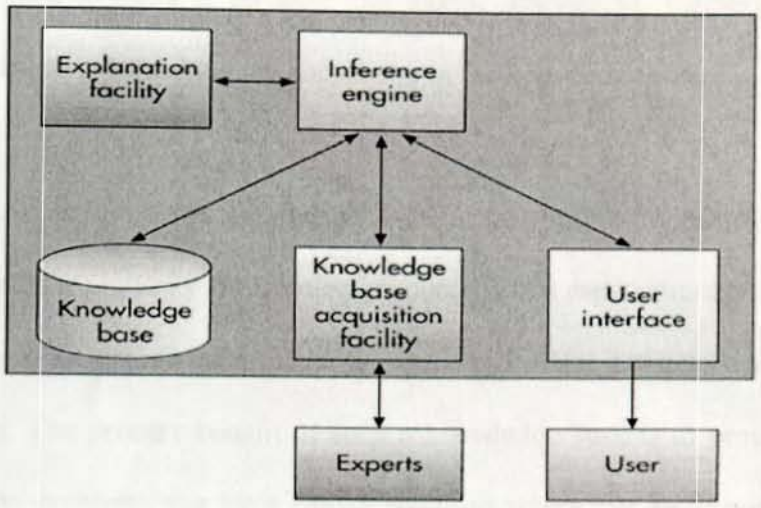


Figure 1.1. Components of Expert System

2.6.2 Components of an Expert System

User is the person (expert or otherwise) who uses the system for support. The end-user usually sees an expert system through an interactive dialog that, for example, proceeds in a dialogue involving questions by the system and answer input by the user.

Expert is a domain expert who input the knowledge into the system during the development and the knowledge acquisition processes described in the following section.

The Knowledge Base stores all relevant information, data, rules and relationships used by the expert system. The knowledge base can store simple if-then statements, fuzzy logic, semantic networks, rules, frames, cases and other.

According to the Wikipedia encyclopedia (2006), knowledge bases are categorized into two major types: Machine-readable knowledge bases store knowledge in a computer-readable form, usually for the purpose of having automated deductive reasoning applied to them. They contain a set of data, often in the form of rules that describe the knowledge in a logically consistent manner. Logical operators such as And (conjunction), Or (disjunction), material implication and

negation may be used to build it up from the atomic knowledge. Consequently classical deduction can be used to reason about the knowledge in the knowledge base.

Human-readable knowledge bases are designed to allow people to retrieve and use the knowledge they contain, primarily for training purposes. They are commonly used to capture explicit knowledge of an organization, including troubleshooting, articles, white papers, user manuals and others. The primary benefit of such a knowledge base is to provide a means to discover solutions to problems that have known solutions which can be re-applied by others, less experienced in the problem area.

The most important aspect of a knowledgebase is the quality of information it contains. The best knowledge bases have carefully written articles that are kept up to date, an excellent information retrieval system (search engine), and a carefully designed content format and classification structure.

Determining what type of information is captured, and where that information resides in a knowledge base is something that is determined by the processes that support the system. A robust process structure is the backbone of any successful knowledge base.

The Inference Engine seeks information and relationships from the knowledge base and provides the answers, predictions, or suggestions using several methods to accomplish these tasks including backward and forward chaining.

There are several characteristics known to be appropriate to a good inference technique.

1. A good inference technique is independent of the problem domain. In order to realize the benefits of explanation, knowledge transparency, and reusability of the programs in a new problem domain, the inference engine must not contain domain specific expertise.

2. Inference techniques may be specific to a particular task, such as diagnosis of hardware configuration. Other techniques may be committed only to a particular processing technique.
3. Inference techniques are always specific to the knowledge structures.
4. Successful examples of rule processing techniques include:

    (a) Forward chaining
    (b) Backward chaining

Forward chaining starts with the data available and uses the inference rules to conclude more data until a desired goal is reached. An inference engine using forward chaining searches the inference rules until it finds one in which the if-clause is known to be true. It then concludes the then-clause and adds this information to its data. It would continue to do this until a goal is reached. Because the data available determines which inference rules are used, this method is also called data driven.

Backward chaining starts with a list of goals and works backwards to see if there is data which will allow it to conclude any of these goals. An inference engine using backward chaining would search the inference rules until it finds one which has a then-clause that matches a desired goal. If the if-clause of that inference rule is not known to be true, then it is added to the list of goals.

For example, suppose a rule base contains two rules:

(1) If a client has multiple sexual partners then he/she has risky sexual behavior.

(2) If a client has risky sexual behavior then they have high risk of exposure to HIV.

Suppose a goal is to conclude that a client has high risk of exposure to HIV. The rule base would be searched and rule (2) would be selected because its conclusion (the then clause) matches the goal. It is not known that a client has risky sexual behavior, so this "if" statement is added to the goal list. The rule base is again searched and this time rule (1) is selected because its then clause matches the new goal just added to the list. This time, the if-clause (the client has

multiple sexual partners) is known to be true and the goal that the client has high risk of exposure to HIV is concluded. Because the list of goals determines which Rules are selected and used, this method is called goal driven.

The inference rule: An understanding of the "inference rule" concept is important to understand expert systems. An inference rule is a statement that has two parts, an if-clause and a then-clause.

An expert system's rule-base is made up of many such inference rules. They are entered as separate rules and it is the inference engine that uses them together to draw conclusions. Because each rule is a unit, rules may be deleted or added without affecting other rules (though it should affect which conclusions are reached). One advantage of inference rules over traditional programming is that inference rules use reasoning which more closely resemble human reasoning.

Thus, when a conclusion is drawn, it is possible to understand how this conclusion was reached. Furthermore, because the expert system uses knowledge in a form similar to the expert, it may be easier to retrieve this information from the expert.

The Explanation Facility allows the user to understand how an expert system arrived at certain conclusions or results. It is very difficult to implement a general explanation system (answering questions like Why and How) in traditional systems. The response of the expert system to the question WHY is an exposure of the underlying knowledge structure. It is a rule; a set of antecedent conditions which, if true, allow the assertion of a consequent. The rule references values, and tests them against various constraints or asserts constraints onto them. This, in fact, is a significant part of the knowledge structure. There are values, which may be associated with some organizing entity.

The User Interface is used for designing, creating, updating and using expert systems. The function of the user interface is to present questions and information to the operator and supply the operator's responses to the inference engine. Any values entered by the user must be received and interpreted by the user interface. Some responses are restricted to a set of possible legal answers, others are not. The user interface checks all responses to insure that they are of the correct data type. Any responses that are restricted to a legal set of answers are compared against these legal answers. Whenever the user enters an illegal answer, the user interface informs the user that his answer was invalid and prompts him to correct it.

Knowledge Acquisition Facility: is used to input new knowledge into the system. In order to input knowledge, modern expert systems are rarely written in a high-level programming language. Instead, they are built in a special software environment, known under various names like expert system shells, expert-system builder tools, or knowledge-based system toolkit. An early example of such an environment is EMYCIN (Essential MYCIN), a system that emerged from MYCIN by stripping it of its knowledge concerning infectious disease.

Other examples, include CLIPS, JESS, AION-DS. Also the PROLOG programming language is eminently suitable to implement expert systems. Every expert system shell or builder tool offers a formal language, called a knowledge-representation formalism, for encoding the domain knowledge in the knowledge base. Furthermore, they provide one or more inference engines that are capable of manipulating knowledge that is represented in the formalism.

The developer of an expert system is therefore shielded from most of the system's algorithmic aspects; only the domain-specific knowledge has to be provided and expressed in the knowledge-representation formalism, whereas the reasoning as offered by the tool may need to be tailored to the type of problem solving required. Note that several advantages arise from the

property that a knowledge base can be developed separately from the inference engine. A knowledge base can be developed and refined stepwise. Errors and inadequacies can be easily remedied without making changes to the program text necessary. Furthermore, an expert-system builder tool can be used to develop expert systems for different problem domains, which may save in development time and costs.

2.6.3 Phases in Expert System Development

Expert system development usually proceeds through several phases including problem selection, knowledge acquisition, knowledge representation, testing and evaluation.

Problem selection: the most critical step in developing an expert system is identifying a suitable problem. Expert systems are best suited to problems that require experience, knowledge, judgement, and complex interactions to arrive at a solution. One of the first tests to determine if a subject area is suitable for an expert system is whether the solution of the problem requires the knowledge and expertise of a human expert.

Knowledge Acquisition: after the problem has been selected, the knowledge acquisition phase of expert system development is begun. The task is to have the knowledge which the expert uses to solve the problem displayed in a logical fashion so that it can be coded into the computer. There are different approaches to acquiring knowledge such as acquisition of knowledge directly from the domain expert(s), acquisition through the use of historical records, etc.

Knowledge Representation: the knowledge the expert uses to solve a problem must be represented in a fashion that can be used to code into the computer and then be available for decision making by the expert system. There are various formal methods for representing

knowledge (such as production rules) and usually the characteristics of a particular problem will determine the appropriate representation techniques employed.

Knowledge Application: In traditional software engineering, testing (verification, validation, and evaluation) is claimed to be an integral part of the design and development process. However, in the field of expert systems, there is little consensus on what testing is necessary or how to perform it. Also, many procedures used for testing were designed to be specific to the particular domain in which they were introduced. The complexity and uncertainty related to these tasks has led to a situation where most expert systems are not adequately tested. (Wentworth, A. J., Knaus, R., & Aougab, H., 1995)

2.7. EXPERT SYSTEMS FOR HIV/AIDS

Among the numerous problem areas that are challenging the medical world, the HIV disease is one to which many lives are currently being lost. Compared to the rate at which the deadly disease is spreading, efforts made to use the expert system technology in tackling the diverse issues of HIV/AIDS seems not to have gained the deserved attention. But this, by no means, undermines the important contribution expert systems can make in assisting health care workers in controlling the pandemic.

The purpose of reviewing some of the areas that have so far been addressed by researchers in the Artificial Intelligence community and academic circles is to demonstrate this very fact.

Generic problem-solving and decision-making are steps in clinical medicine that are conceptually represented in expert systems by two subsystems: diagnostic and therapeutic modules respectively. As it specifically applies to the HIV disease, one problem area that needs to be solved is "how to select the best possible combination of drugs that can be effective in eradicating HIV infection, or prolonging a patients progression to AIDS" (CCEBRA, 2002).

The challenge in treatment decisions can, therefore, be said to have become more complex, "requiring an understanding of viral pathogenesis, antiretroviral resistance patterns, and use of laboratory markers of HIV disease progression and antiretroviral efficacy" (CCEBRA, 2002).

An Expert System Model for Selecting Antiretroviral Treatment of HIV/AIDS Complex was developed as an interactive system that provides decision-making information on appropriate therapeutic treatment for patients living with HIV/AIDS. For a specific patient, the expert system for selecting antiretroviral treatment makes an assessment of disease progression risk based on a set of clinical findings such as signs, symptoms, laboratory data and so on.

After analyzing the conditions that apply to the patient, the system finally recommends the appropriate treatment plan. The overall objective of this system is, therefore, to "provide clinical recommendations for antiretroviral therapy for human immunodeficiency virus (HIV) disease with currently available drugs" (CCEBRA, 2002).

The interactive system starts by presenting background information to the user and proceeds to accept input, which it uses for decision-making purposes and drawing conclusions. The expert system kernel, Nexpert Object, was used to determine the clinical HIV infection status, and disease progression risk of the patient.

Furthermore, expert advice can be acquired from the system on whether antiretroviral therapy should be administered, if and when prophylaxis for vertical transmission, prophylaxis for post-exposure transmission, and antiretroviral therapy for primary infection should be administered. It also provides the recommended drug and dosage for each of these conditions.

After reaching conclusion and making decisions, the system displays the result to be viewed by the user. A summary of the inference session is then provided on conclusions/hypothesis and the outcome of their evaluation, supportive evidence for all decisions made and conclusions reached, suggestive evidence for why conclusions/hypothesis were established, and counter arguments for why conclusions/hypothesis were rejected (CCEBRA, 2002).

A research was undertaken in partial fulfillment of the requirements for MScIS at the Addis Ababa University, Faculty of Informatics, Department of Information Science is another notable example in the area. ExpART, which stands for an Expert system in Anti-Retroviral Therapy, is the prototype developed by Anteneh Worku in June 2004.

Knowledge Pro Gold version 3 was the expert system shell used for representing the required knowledge as well as designing the user interface of ExpART. The knowledge for this rule-based system was mostly acquired from textbooks on antiretroviral therapy. ExpART was later evaluated by physicians, who testified to its accuracy and usefulness in the decision-making process.

EXPERT AIDS 7.0 is another expert system designed for problems concerning AIDS and different current treatments. The knowledge-base uses both qualitative and quantitative information in which new rules and operators can also be included. The system is educational and, according to Societe De Bio-Informatique et de Bio-Technologie, also "creates and visualizes reactions owing to therapeutic research and diagnosis". One of the modules contained therein is dedicated to "the treatment of opportunistic diseases by polytherapeutic agents" (Societe De Bio-Informatique et de Bio-Technologie).

Customized Treatment Strategies for HIV (CTSHIV) is a rule-based expert system that is developed to address the rapid mutant nature of the HIV virus and the associated problem of

drug-resistance. The system "encodes information from the literature on known drug-resistant mutations" and contains rules that include "ranking and weighting based on antiviral activities, redundant mechanisms of action, overlapping toxicities, relative levels of drug-resistance, and proportion of drug-resistant clones in the HIV quasispecies" (JAIDS, 1997). The direct input the CTSHIV program requires is the patient's RNA sequencing data, which it uses to recommend the five most effective drug regimens together with an explanation for their choice.

The recommendations are provided by CTSHIV based on information in the current medical literature on drug-resistant mutations. Thus, the expert system is an effective tool in the design of clinical trials as well as management of HIV-infected patients (Journal of Acquired Immune Deficiency Syndromes, 1997).

The Computerized Medical Record ADDIS was developed at the Nice University Hospital with the principal objective of increasing "the availability and the reliability of the information contained in the medical file, in order to facilitate the communication between the various staff members" (Pradier, C., Pugliese, P., Caissotti, C., Wehrlen-Martini, S., Huynh-Van, E., Pueyo B, Dellamonica P., 1998). The computerized medical record was in use since 1994 and comprises of a database containing a record of more than 1,300 patients and 6,000 entries.

Clinical trial and prescriptions of antiretroviral therapies are the two areas handled by the expert system. In the first one, clinical and biological data entries acquired during consultation are used to suggest to the physician the potential inclusion of the patient in a clinical trial. The expert system analyzes clinical data (CDC stadge), therapeutic data (former and current antiretroviral therapies), and biological data (CD4 cell count and HIV viral load) (Pradier, C., et al., 1998).

For prescriptions of antiretroviral therapies, the expert system analyzes the posology and the rhythm of administration seized by the doctor during the consultation. It compares then these data with the guidelines implemented in the software. If it finds an inadequacy between the seized data and the authorized regulations, it proposes to the doctor the regulation recommended for this antiretroviral (Pradier, C. et al., 1998). The doctor, however, is free to prescribe antiretroviral in spite of what is not recommended by the system.

AD-Knowledge Base-01: this Knowledge Base is designed as a dynamic summary of the emerging results from 10 Adolescent Care Projects originally funded in 1993 by the Special Projects of National Significance (SPNS) Program of the HIV/AIDS Bureau of the Health Resources and Services Administration (HRSA) in the United States. Funding for the projects continued through December 1998. The target populations of the projects were adolescents and youth who are either already infected with HIV or at high risk to become so. This Knowledge Base is designed to present emerging results from the projects. Many of the Knowledge Items are derived from quantitative data while others derive from qualitative information (Huba, G. J., Melchior, L. A., Panter, A. T., & the Project Directors, 2005 update).

TherapyEdge-HIV is a Web-based software program developed in July 2002 that employs artificial intelligence to assess a patient's clinical status, alert for potential medical issues, and present viable, individualized therapy options based on their likelihood of success, in real time. TherapyEdge-HIV graphically tracks and automatically processes a patient's clinical data – including medical conditions, medications, genetic tests for drug resistance, drug efficacy, and toxicity data – through an extensive knowledge base of pharmacological and clinical information. These knowledge bases are created and continuously maintained in collaboration with world-renowned HIV clinicians and researchers. The system's intelligent alerting system checks for drug interactions, medical conditions or side-effect issues, as well as abnormal lab results and drug dosing (International Association of Physicians in AIDS Care, 2002).

AIDS2: A Decision-Support Tool for Decreasing Physicians' Uncertainty Regarding Patient Eligibility for HIV Treatment Protocols was designed to assist in the task of matching patients to therapy-related research protocols. The purposes of AIDS2 are to determine the initial eligibility status of HIV-infected patients for therapy-related research protocols and to suggest additional data-gathering activities that will decrease uncertainty related to the eligibility status. AIDS2 operates in either a patient-driven or protocol-driven mode. AIDS2 provided meaningful advice in all the 10 cases that it was tested on. (Ohno-Machado, L., Parra, E., Henry, S. B., Tu, S. W., and Musen, M. A., 1993)

2.8. APPLICABILITY OF EXPERT SYSTEMS FOR HIV/AIDS IN ETHIOPIA

The rationalization for applying expert systems to problem solve HIV/AIDS issues in Ethiopia has partly been explained in the 'justification of the study' part (chapter I) of this Thesis. Moreover, the applicability can generally be weighed against the following factors:

- Availability of resources:
  - Time: although the timeframe given to develop this research is limited, generally, there is no time constraint to apply expert systems in Ethiopia for HIV/AIDS.
  - Finance: with the amount of investment that is being pumped into researches related with HIV/AIDS both by governmental and non-governmental institutions in the country, an effort to build an expert system in the area will not be faced with shortage of finances for the purpose.
  - Domain Experts: nearly all health care institution in Ethiopia have an HIV/AIDS focal person who have specialized in certain areas of the problem (such as giving voluntary counseling and testing). The variety of printed and online resources regarding

HIV/AIDS in Ethiopia also makes the availability of domain experts a less challenging task.

- Knowledge-engineer: compared to the areas where expert systems can be applied in relation to HIV/AIDS, the availability of local nationals who are likely to engage in engineering knowledge into an expert system is quite limited, yet sufficient.

- Demand: with the horrifying statistics regarding the spread of the HIV virus, it would be difficult to say that current efforts to put this deadly disease under control are being met with a proportional response. This, by itself, calls for a need to avail at least a portion of the general public with new ways of protection against the HIV virus, which deviate from the traditional ways of sensitization and information giving.
- Practicality/appropriateness: problems relating to HIV/AIDS are of huge concern in such developing nations as Ethiopia, and any enhanced or fast solution to existing problems in the domain (such as expert systems) will contribute positively to the global fight against the virus.
- Benefits: the availability of expert systems in the area will provide both users and experts the alternative solution method with less time and funds.
- Target group: developing expert systems in HIV/AIDS will give an opportunity to address the issue particularly to the youth population in an attractive and more practical manner.

As we have seen so far, there are numerous areas where expert systems can generally be applied and various attempts have been made to develop expert systems in relation to medicine in general and HIV/AIDS in particular. Despite this fact, however, one major area still remains unexplored by the technology, i.e. Voluntary Counseling and Testing (VCT). A couple of areas where expert systems can be applied in relation to VCT are tutoring/training HIV counselors, and administering VCT. This research is one of these attempts to address this particular area of the many HIV prevention strategies, namely VCT.

CHAPTER THREE
HIV/AIDS COUNSELING

3.1. BACKGROUND

AIDS is a disease that has spread like wildfire throughout Ethiopia within a relatively short time, currently accounting for about one-third of all young adult deaths in the country (Centers for Disease Control and Prevention, Global AIDS Program). According to the July 2005 statistical estimates, the population of Ethiopia is about 73,053,286. This estimate has explicitly taken into account the effects of excess mortality in the country due to AIDS, which implies a lower life expectancy, higher infant mortality and death rates, lower population and growth rates, and changes in the distribution of population by age and sex than would otherwise be expected (The World Fact Book, 2005).

The number of lives lost to AIDS was an estimated cumulative total of 900,000 by 2003 and, if present trends continue, is projected to reach 1.8 million by 2008. The 2004 update of WHO/UNAIDS epidemiological fact sheets on HIV/AIDS and Sexually Transmitted Infections indicates that, there are 1.5 million people living with HIV/AIDS (PLWHA), out of which 1.4 million are adults between the age of 15 and 49 (770,000 of whom are women) and the rest 120,000 are Children between 0-15 years (WHO/UNAIDS, 2004). Estimated number of children who have lost their mother or father or both parents to AIDS and who were alive and under age 17 at the end of 2003 were 720,000 (WHO/UNAIDS, 2004).

As can be projected from statistical evidence available, adult (15-49 years) deaths due to AIDS are expected to rise in the coming years (CDC, GAP). With a 4.4% (12.6% urban and a 2.6% rural) adult prevalence rate of HIV/AIDS, an estimated 1.5 million PLWHA, and

120,000 HIV/AIDS deaths within the year (The world fact book, 2003 estimates), it is not surprising that the active search for and planning towards an effective preventive mechanism that refuses to give more lives to the disease continues to be one of the top agendas of the country.

Diversified efforts are being undertaken on individual, family, community, institutional, regional and national levels to provide preventive, treatment and care facilities for HIV/AIDS. Particularly the past five years have been a period that witnessed more and more aggressive planning that directly or otherwise involved VCT services.

VCT is one of the 10 focal strategies that are proposed in the comprehensive HIV/AIDS policy and five-year national strategy framework released by the Government of Ethiopia from the year 2001 to 2005. In addition to HIV testing and counseling, Center for Strategic and International Studies (CSIS) Task Force on HIV/AIDS reports that the proposed strategies include behavioral change, condom promotion and distribution, STD prevention and control, safe blood supply, surveillance, notification and reporting, and the provision of medical care and psychosocial support to those affected by HIV/AIDS.

The Strategic Framework for the National Response to HIV/AIDS in Ethiopia for 2001–2005 guides HIV/AIDS programming. To improve program effectiveness under the strategic plan, the government is moving all of its HIV/AIDS coordinating bodies under the direction of the Ministry of Health (MOH). Following the Global Fund to Fight AIDS, Tuberculosis and Malaria (the Global Fund), U.S. President George W. Bush's Emergency Plan for AIDS Relief (the Emergency Plan) is the second largest donor in the HIV/AIDS sector in Ethiopia (CDC, GAP). Recognizing the global HIV/AIDS pandemic as one of the greatest health challenges of our time, Emergency Plan was announced in 2003 – the largest international

health initiative in history by one nation to address a single disease. The Emergency Plan response includes (CDC, GAP):

- Leveraging and complementing resources and commitment of other partners, including international donors and Ethiopia's public and private sectors;
- Expanding work with new partners, particularly nongovernmental, community-based and faith-based organizations to ensure coverage and foster sustainability;
- Mobilizing private health care providers for quality prevention, treatment and care;
- Supporting the development of national prevention, care and treatment guidelines and protocols, establishment of the structure and systems for effective implementation of the HIV/AIDS program, and human capacity building through training and site level support; as well as
- Strengthening Ethiopia's military HIV/AIDS response with program services for civilian communities around rural military health establishments, as well as active duty personnel and their dependents.

Ethiopia is one of 15 focus countries of the Emergency Plan which collectively represent at least 50 percent of HIV infections worldwide. Under the Emergency Plan, Ethiopia received more than $47.9 million in 2004 to support a comprehensive HIV/AIDS prevention, treatment and care program. In 2005, the U.S. is committing more than $84.4 million to support Ethiopia's fight against HIV/AIDS (CDC, GAP).

Critical Interventions for HIV/AIDS Prevention

- Supporting youth peer education and life skills programs for in and out of school youth, anti-AIDS youth clubs and religious youth groups that develop the knowledge of HIV/AIDS and life skills of youth.

- Directing comprehensive behavior change communication programs targeting most-at-risk populations to reduce the number of persons who engage in risky behavior.
- Providing mass media and community programs for the general population to increase knowledge of HIV transmission and prevention methods.
- Mobilizing religious and community leaders to support HIV prevention, care, and support programs and also to reduce the stigma facing people living with HIV/AIDS.
- Supporting expansion of voluntary HIV counseling and testing centers and implemented a promotional campaign called "Knowing is a modern way of living" to increase awareness of HIV status and increase the number of individuals tested.
- Supporting strong partnerships for prevention and care services with faith-based organizations, particularly the Ethiopian Orthodox Church and the Islamic Supreme Council.

Critical Interventions for HIV/AIDS Care

- Supporting expansion of home-based health care for people with AIDS by partnering with traditional burial societies known as 'Idir'. The respect held for idirs in the community is helping to reduce the stigma surrounding those with AIDS.
- Contributing to the production of the first song and music video that promotes compassion and caring for people living with HIV/AIDS. It has become a big hit, and people of all ages have embraced it.
- Developing a national program to strengthen and support local grassroots organizations for the provision of services for HIV and AIDS orphans and vulnerable children.
- Supporting important linkages between TB and HIV services, a critical pathway to improve patient care and reduce the burden of TB.

- Providing care and support in 18 towns along the Addis Ababa – Djibouti corridor, working with Community HIV/AIDS Committees, to provide an entire community care package.

Critical Intervention for HIV/AIDS Treatment

- Strengthening leadership at central, regional and facility levels by supporting establishment of an effective management system in the Ministry of Health and the creation of a National HIV/AIDS Executive Committee.
- Assisting in the selection of hospitals for antiretroviral therapy (ART) implementation in the country and in assessing, prioritizing and preparing them to meet the minimum package for accreditation to deliver ART.
- Supporting laboratory services through a consortium of private laboratories that guide initiation and monitoring of ART, procurement of laboratory supplies and reagents, and lab maintenance.
- Supporting assessment of capacity for pharmaceutical management system in hospitals, to support ART services, renovation of facilities, procurement and distribution of drugs, and human capacity development for delivery of ART services.
- Creating linkages between hospitals, health centers and the community to facilitate delivery of treatment, follow-up of clients, and referral to community and home based care.

The above-mentioned prevention and care results reflect accomplishments through September 2004, while treatment results reflect accomplishments through March 2005 (CDC, GAP).

Moreover, some of the actions taken on governmental level also include developing policies and manuals addressing surveillance, voluntary counseling and testing, behavioral change communication, prevention of mother-to-child transmission, sexually transmitted infections, and monitoring and evaluation. Some voluntary counseling and testing pilots are already functioning (CDC, GAP).

In addition to recognizing HIV/AIDS as a health, developmental, political, economic and social problem, effective implementation of such plans aim at reducing HIV transmission and lessening the burden of HIV/AIDS on individuals, families, and the society at large (CDC, GAP).

The following sections will give an overview of VCT in Ethiopia, the challenges faced, opportunities to be tapped, its general administration, and monitoring and evaluation aspects.

3.2. VOLUNTARY COUNSELING AND TESTING IN ETHIOPIA: AN OVERVIEW

According the national guideline of VCT in Ethiopia, the objectives of voluntary HIV counseling and testing is (UNICEF, 2001):

1. To provide information on the mode of HIV transmission and method of prevention.
2. To help those who wish to consider HIV testing make their own decision whether or not to be tested and to provide support following the testing.
3. To provide information on the increased risk of HIV transmission associated with other sexually transmitted infections (STIs) and give referrals for STI examination and treatment.
4. To provide information on the increased risk of opportunistic infections including tuberculosis associated with HIV infection

5. To provided family planning information and referral for women of child bearing age who are infected or are high risk of HIV infection, and
6. To provide referrals to HIV positive and high risk HIV negative persons for necessary medical, preventive and psycho-social services and home based care in the community.

Unfortunately, various reports clearly indicate that the number of people in Ethiopia who are being tested to know their HIV status is too small. The sad fact remains that there are many infected people who have not yet been diagnosed, including those whose lifestyles and behavior puts them at risk. HIV transmission is particularly high in Addis Ababa, with a prevalence of 15%, and intense commercial sex work is likely to increase the transmission rate in this area. Youth in the 15 to 24 years age bracket have the highest HIV/AIDS prevalence in Ethiopia (12.1%). Most are not married, and many have multiple sex partners (John Nduba, J., and Delnessa, T., 2004).

Leading NGOs such as the Family Guidance Association of Ethiopia have integrated Voluntary Counseling and Testing (VCT) services with Sexually Transmitted Infections (STI) treatment into existing family planning services, and newly established NGOs have engaged their field staff in undertaking comprehensive awareness creation on HIV/AIDS, leading to increasing number of community members patronizing the activities of VCT centers. Whatever the means, a dedicated group of NGOs is managing to reach the Ethiopian people and bring about small changes in the remote communities of Ethiopia (Focus on Ethiopia, 2004).

3.2.1 VCT Centers

At the end of 2004, the Centre for Disease Control in Ethiopia emphasized the need to expand voluntary HIV/AIDS counseling and testing (VCT) centers in order to stem the tide

of the pandemic. According to the UN Aids programme, UNAIDS, there are some 282 VCT centres in Ethiopia - a 60 percent increase in the number of centres countrywide. Expansion of VCT centres was crucial in impeding the spread of the virus (UN Office for the Coordination of Humanitarian Affairs, 2004).

3.2.2 Administration of VCT

Voluntary counseling and testing requires time, acceptance, accessibility, accuracy, consistency, and confidentiality. WHO states that VCT service should clarify and address problems, provide information on available resources, help client to adopt a realistic approach to changes of life style, should motivate and facilitate decision making (UNICEF, 2001).

In Ethiopia, VCT is administered by giving clients as much time as they would require, depending on the complexity of problems and customized need of the person. Appropriate counseling techniques are adopted and given by trained medical doctors, nurses, or people who have received special training on VCT. The stigma associated with HIV positive people, and the cultural barrier towards discussing one's personal sexual history with others makes it difficult to register the desired level of VCT acceptance.

Accessibility of VCT is generally limited to urban centers in the country. The rural places are, therefore, still remains largely deprived of near access to VCT centers. But in areas where VCT is administered, confidentiality is maintained through the use of client identification codes (instead of using the name of the individual receiving the counseling and testing). In some places, accurate test results are given to clients on the same day, while in others, results may take time as they require the number of people who are testing in the health facility to reach a certain number before the tests are performed.

All in all, most health facilities in Ethiopia seem to provide adequate and proper room space conducive to administration of VCT services. Attempts are also being made to meet the biggest challenge in hospitals, that of providing personnel who could be assigned to VCT services on full time basis. Attracting uninfected people to health care facilities has a great potential to broaden the administration of VCT and prevention information, thus enhancing the scope of overall preventive activities.

3.3. CHALLENGES AND OPPORTUNITIES: SITUATION IN ETHIOPIA

Understanding the obstacles and opportunities to increase the quality of administering (availability, accuracy, confidentiality, etc.) VCT requires the problems and options to be put in the larger context of the HIV/AIDS situation in Ethiopia.

3.3.1. Challenges

In Ethiopia, HIV/AIDS occurs within the exceptionally challenging environment of multiple threats and constraints. Abject poverty, low investments in public health, a stagnant economy, high unemployment, recurrent food crises, a heavy disease burden, and exceptionally weak state social service capacities are only a few of the problems that earned the country the term "a constellation of challenges" (Cooke, J. G., 2004).

Although Ethiopia is not the only country that hosts a wide variety of problems, by and large the constraints are, as described by Cooke, J. G. (2004) "conspicuously more acute in Ethiopia". The 2004 Human Development Report of the United Nations Development Program (UNDP) ranks Ethiopia 170 out of 177 on the Human Development Index; 92 out of 95 on the Human Poverty Index; and 137 out of 144 on the Gender-related Development Index.1. Further, Cooke (2004) mentions that Ethiopia's sheer size of over 70 million citizens compounds the difficulty of addressing these constraints effectively.

Ethiopia's per capita government spending on health – just over $1.00 in 2001 – is the lowest in Africa. Total per capita health expenditure – $3.00 – is second-lowest in Africa, barely edging out Liberia. Currently, there are 2,032 physicians in Ethiopia – one doctor for every 34,000 people – and 40 percent of the population has no access to modern healthcare of any kind (Cooke, J. G., 2004).

Below are a few more challenges Ethiopia has been and is still facing, which contribute to or are causes for the largely unsuccessful fight against HIV/AIDS in the political and socio-economic arenas (CSIS Task Force on HIV/AIDS):

- An exceedingly weak public health system with little experience and no successful model of mounting broad-scale public health programs
- Vulnerability to recurrent food insecurity and famine.
- Lack of baseline data and the absence of any meaningful evaluation mechanisms that could have grave short and long term implications.
- Speedy progression of the pandemic driven by unprotected sex, the high frequency of casual partners, commercial sex work, and hopelessness among youth due to poverty and unemployment.
- Gender inequality and women's inability to defend against unsafe sex, abduction, early marriage, domestic abuse, rape, and female genital mutilation.

The challenging task at hand is, therefore, to balance prevention, care, treatment, and broader health-related goals; and striking a balance between a short-term emergency response and a long-term sustainable strategy. In another perspective, the hope of controlling the spread of HIV/AIDS through individual behavioral change is also met with another set of

obstacles/challenges. Case studies further shed some light on the specific HIV/AIDS challenges associated with particular groups of the population (youth, women, etc.). Some of these challenges are (UNICEF, 2001):

- Lack of knowledge and information about reproductive system, anatomy, how pregnancy or STI occur, how to prevent them and where and how to obtain protection;
- Insecurity about the future due to unavailability and unaffordability of ARV;
- Lack of up-to-date scientific information on contraceptive safety protection;
- Requirements for medical tests and pelvic exams that discourage young people from seeking contraceptive;
- Strong taboo held by parents against talking about sexual matters with their children.
- Opinions shared by religious leaders, which considers HIV/AIDS as retribution for sin rather than as a health and social matter that everyone faces.
- Cheap, illegal movie houses where alcohol is served while watching pornographic films.

Each aspect of HIV/AIDS prevention is also faced with its own challenges. For instance, some of the key challenges of VCT involve such issues as:

- Low popular perception of individual risk, a lack of understanding of behavioral risks, pervasive silence, stigma, and denial surrounding the disease.
- Cultural barriers, notably secrecy and conservatism around sex, also hinder effective action.
- Psychological or social barriers that prevent adolescents from admitting that they are having sex.
- Unrealistic views of individual pregnancy and STI risks – the "it cannot happen to me" syndrome;

- Fear and embarrassment of young people and women to seek help because of rape or incest.
- Lack of access to services and programs due to financial constraint, lack of transportation, or information on how to use services;
- Judgmental attitudes of health workers toward adolescent sexual activity; and
- Inconvenient hours or location, unfriendly staff and lack of privacy for using reproductive health services.

As it can be seen from the challenges, approaches to HIV/AIDS that do not take into account the fragility of Ethiopia's socioeconomic circumstances will have a high probability of failure. Far from being exhaustive, the above-mentioned examples are only meant to highlight the complexity and depth of the bottlenecks in the country's fierce struggle and urgent need to put a stop to HIV/AIDS. But the existence of many problems also presents an equally vast opportunity to tackle the challenges both collectively and individually.

3.3.2. Opportunities

Being one of the top items on the country's health agenda, increased funding is available from governmental and non-governmental organizations that specifically work on HIV/AIDS. This presents an opportunity to improve different type of services, such as VCT, antenatal care services, media education, etc.

Moreover, the long road that should be traveled before Ethiopia can safely remove the HIV/AIDS concern from all economic sectors points to many areas where the gap should be bridged. Thus, there are opportunities to (Bohmer, L., 2004):

- Integrate voluntary counseling and testing as part of other efforts such as safe motherhood, malaria control, integrated management of childhood illness, PMTCT in the broader community
- Integrate family planning and HIV/AIDS prevention efforts
- Improve care and support for positive women and their families
- Integrate within existing youth-driven prevention activities, Anti-AIDS clubs etc.
- Use the fact that more women and girls are HIV positive to direct attention to the role that gender discrimination and gender-based violence in increasing risk
- Provide PLWAs with opportunities to gain skills in counseling and other care and support activities (move from victims to key actors)
- Prioritize pregnant positive women for free ARVs.

Plenty of opportunities also exist to make further research and assessment in the specific areas of (John Nduba, J. et al., 2004):

- Risky sexual behaviors among the youth.
- Challenges in communicating with the youth about safer sex practices.
- Strategies for dealing with risky behaviors for more effective HIV prevention
- Sensitizing parents on how to give youth the help and information they need.
- Designing integrated approaches to reach parents, religious leaders, bar and video housekeepers, farmers and their families, and commercial sex workers to complement interventions targeted at youth.
- Coming up with programs that specifically address the need for girls and young women to counteract the oppressing poverty that channels them into commercial sex work.
- Economic empowerment and education for girls/women

- Designing effective messages that encourage adoption of more responsible sexual behaviors but also avoid stigmatizing those who are infected.

Successful implementation of the above mentioned opportunities require caution and flexibility in setting targets for treatment, care, and prevention. Development and implementation of a comprehensive, common HIV/AIDS monitoring and evaluation framework would also be useful in paving the way for ceasing available chances to gain victory in the great war against this global pandemic.

Continuing to promote measures that prevent the further spread of HIV/AIDS, while providing appropriate care and support to all those who have been infected or affected by HIV/AIDS, will require careful and consistent collaboration between government and private-sector organizations, community groups, and individuals. Every sector, and every level, of society must be involved to rise up to the challenges and tap opportunities to mitigate the effects of the HIV/AIDS epidemic in Ethiopia.

3.4. ACCESS TO VCT

The effort to increase awareness of the public towards HIV/AIDS has resulted in an increased demand for related services in Ethiopia, especially by HIV positive people. However, the existing system is not supported by a user-friendly service infrastructure that can give an immediate response to such needs. VCT centers remain limited in number compared to the population that need to benefit from their services. According to the CSIS Task Force on HIV/AIDS, even the existing counseling and training centers are "almost without exception urban-based, and are provided by local and international NGOs rather than the Ministry of Health".

The services providers of the VCT centers in urban areas are government hospitals, NGOs, and a few private clinics. In some centers, the cost of testing still remains too high for the majority of the population but in many instances, fees associated with testing are largely subsidized by NGOs to make VCT services accessible to people with low economic standards.

Despite the fact that VCT services are opened in various urban centers, lack of customized counseling and training techniques that address the needs or are capable of attracting individuals such as in and out of school youth makes VCT inaccessible to an important segment of the population.

3.4.1. Monitoring of VCT

According to WHO/UNAIDS, the main advantages of evaluation lie in that it highlights (WHO/UNAIDS, 2004):

- Areas that need development and improvement to meet the changing needs of people attending VCT,
- The different therapeutic options available; and
- The ongoing training and development needs of health and counseling staff.

Ethiopia has yet to implement a common HIV/AIDS monitoring and evaluation framework that can be applied nation-wide for standardized adoption and application by HCPs.

- ***Quality Assurance***

Some of the mechanisms for analyzing and providing accurate feed back to VCT sites and counselors are: client exit interviews, counselor interviews, observations of counseling sessions, and "mystery clients".

Client and counselors can each give first hand information on the aspects of VCT from two different perspectives. Their experience is, therefore, a good basis for monitoring and evaluation of VCT. A simple observation technique wherever permission is obtained from the client can also be adopted to make improvements and thus increase the quality of actual VCT sessions. The observer can also appear as a client (without informing the counselor that the session is conducted for monitoring and evaluation purposes) and make a genuine observation of the counseling techniques used by the counselor.

3.5. ELEMENTS OF A TYPICAL SESSION

According to information acquired from the VCT guide of Center for Disease Control, global AIDS program, Bethezatha hospital, and various VCT counselors in Addis Ababa, the Voluntary HIV counseling and Testing Intervention Protocol has two sessions. These are: an initial session and a secondary session, which are generally known as the pre-test and post-test counseling respectively.

As the pre-test session will be discussed in great detail in the next chapter, the general variables involved in post-test counseling are discussed below.

3.5.1. Second session/Post-test counseling

A VCT counselor provides post counseling for HIV negative and positive results in a series of four steps. Each of these steps involves further levels that helps to meet the four major objectives in informing the client about either type of results. The protocol components of the second session (post-test counseling) for both negative and positive results are more or less the same. However, although the sessions share some similarities in the procedures,

there are clear differences in the discussion to be held with clients with an HIV positive and negative results.

Most of the protocol components of the post-test VCT session involve information and discussion that will help negotiate plans with the client. The decision that the counselor would have to make in the post-test session have to do with determining the plan appropriate for specific clients based on information rendered by the individual regarding their living conditions, future plan, etc.

The laboratory results of HIV tests are revealed to a client through a counselor regardless of the results being negative or positive. Post-test VCT counseling is thus a follow-up session that has two components:

- Negative test result, and
- Positive result session.

For HIV positive test results, a counselor would first handle the issue of who will provide support to the client before negotiating disclosure, partner referral and risk reduction. In the case of HIV negative clients, however, a counselor will first handle risk reduction plan before identifying support for risk reduction, negotiating disclosure, and partner referral.

Most of the steps for negotiating disclosure and partner referral are more or less the same for HIV positive or negative client. The major difference, however, lies in giving an HIV positive person a more detailed assistance during the consultation in certain areas such as the best ways to identify partners who might be at risk and in handling issues of disclosing the news for those partners.

The final topic in providing counseling for an HIV positive person is addressing risk reduction issues. On the other hand, for HIV negative clients, this step is carried out immediately after providing them with their HIV test results. Apart from the order in which advice is given, the actual plans for reducing risk of acquiring or transmitting HIV also differ in content and depth. The specific issues are addressed using different questions.

In negotiating risk reduction issues, emphasis is placed in protecting HIV negative people from acquiring the disease through those who are already infected by the virus. Thus, more time may be spent to come up with a strong plan with an HIV negative client that will enable him/her to stay negative. Similarly, while negotiating the plan with an HIV positive client, the focus may be on how to enable them to protect themselves from transmitting HIV to their future partners.

This session is also where the counselor helps the client to identify whom s/he would like to tell about his/her positive test results. In the process, the client will be assisted to come up with the person who is most supportive of them in dealing with their HIV positive situation, someone trustworthy and capable of keeping the client's test results confidential.

The counselor also makes the client aware about the importance of discussing this test result with his/her doctor. The next tasks involve the issues of:

- Access to medical services
- Medical follow-up
- Pregnancy:
  - Finding out any possibility that the client is pregnant, the plans for having children, and the availability of family planning services.
  - The overall discussion on identifying sources of support and providing referrals, involves discussion about Health care provides (HCPs),

- Access to medical services
  - Sexually transmitted diseases exam
  - Tuberculosis evaluation, preventive therapy
  - Family planning
  - Prenatal HIV prevention
  - Routine medical care
  - Identifying needed medical referrals
- Confidentiality
  - Situations in which the client may want to consider protecting his/her own confidentiality
- Options of **support groups**

i) Disclosure and partner referral plans

The points of discussion under this topic of the second session for an HIV positive client are the following:

- **Sharing result with partners**: exploring client's feelings about telling partners about his/her HIV positive test result
- **Partner's HIV status**: reminding client that his/her test result does not indicate partner's HIV status
- **Identifying partners at risk**: listing partners that are at risk and need to be informed of their risk for HIV infection
- **Disclosure of serostatus to partners**: discussion on possible approaches
- **Partner reactions**: an anticipation of potential reaction
- **Partner referral**: supporting client to refer partner for testing
- **Approaches to disclosure**: practicing and role-playing

- Providing the client with **support**
- Assessing **client's plan**:
    - To reduce risk of transmission to **current partners**
    - For reducing the risk of transmission to **future partners**
- **Disclosure** of HIV status to future partners, and
- **Protecting others** from HIV.

ii) Risk reduction plan

The last session is dedicated to addressing risk reduction issues. The main points addressed here have to do with reducing the risk of transmitting the virus to the existing (if any) partner(s) of the client as well as to the future partner(s) the client is likely to establish relationships with.

- Current partners:
    - Assess client's plan to reduce risk of transmission
- Future partners:
    - Explore client's plan for reducing the risk of transmission
    - Address disclosure of HIV status
- Others:
    - Encourage the client to protect others from HIV

Discussion on risk reduction concludes the second and last session of the VCT protocol. Considering the various issues that have been raised and discussed with the client, it is safe to suggest that VCT empowers the person receiving counseling with the ability to either protect oneself or present the infection of others with this deadly disease.

The general objective of this chapter was to highlight the HIV/AIDS situation in Ethiopia, and specifically give the facts and figures associated with applying such preventive measures as VCT. Efforts that have been and are still being made to address HIV/AIDS, the challenges the country continues to face in attempting to free itself from the captivity of such a deadly disease that, unfortunately, has repercussions in all sectors of the economy.

CHAPTER FOUR
KNOWLEDGE ACQUISITION

4.1. INTRODUCTION

Knowledge acquisition is the task of transferring knowledge from humans to computers (Aroyo, L., 2006). In the words of Stefik (1995), Knowledge Acquisition is "any technique by which computer systems can gain the knowledge they need to perform their task." Accordingly, the main objective of this chapter is to obtain and analyze the basic variables in a VCT session in order to transfer into a program the knowledge of what a counselor does when counseling a client.

In this research, this transformation process, generally known as knowledge acquisition, started with a pilot study undertaken in order to come up with a proposal for the study. Different experts in the area (VCT counselors) were then contacted, out of which 5 were selected for the unstructured interview that revealed the knowledge outlined in this chapter. Since most VCT counselors in Addis Ababa use a standard counseling technique that is customized towards the culture and other specific needs of the society, acquiring knowledge from five professionals in the area was deemed sufficient for the purpose of this research.

4.2. STEPS IN KNOWLEDGE ACQUISITION

Concepts needed for conducting a VCT session were learned in consultation with counselors from Black Lion Specialized Referral Hospital, Bethezatha Hospital, United Nations Health Centre, St Gabriel Hospital, and Blue Nile Higher Clinic. Important variables were identified both from counselors and manuals, and refined through consultation with the experts.

A hierarchical tree structure is then used to model the concepts defined, where the goal is put at the highest level of the hierarchy and factors leading to that goal or decision are represented down the hierarchy. The major advantages of the hierarchical tree modeling are its ease of use and simplicity to explain facts represented in the tree. In this method, the primary variables are the nodes nearer to the top of the tree. An ellipse in hierarchical modeling depicts concepts, while arrows are used for connecting nodes, the direction of arrows being from the higher to the lower. Nodes succeed each other until they reach the n^{th} level where there could be no further successors. This method in which general concepts are represented initially followed by the specifics is an instance of the top-down or deductive approach in knowledge acquisition and Representation.

The concept of hierarchical modeling is depicted using trees and practical incidents from the knowledge-acquisition process in the following section.

4.3. CONCEPTUAL MODELING

In this research, discussion with domain experts have revealed that counselors in Addis Ababa generally undertake VCT based on the standard guideline from Centre from Disease Control. The guideline involves protocols under pre- and post-test counseling which are used as variables for this research. According to the domain experts, all variables in the guideline for voluntary counseling should be considered in order to help the client make a well-informed decision about testing (in pre-test counseling) and design an effective risk reduction plan (in post-test counseling). On the basis of this guidance, the researcher is faced with the challenge of modeling all variables in VCT for HIV so as not to leave out any of the variables that are considered important by the experts in the area.

Considering the complexity of attempting to cover such a wide scope, the researcher has resorted to focusing the conceptual modeling task on pre-test counseling. The decisions that have to be made in pre-test counseling far exceed those that have to be made in post-test sessions. Thus, demonstrating the procedures for decision-making in pre-test counseling is believed to be much more significant for the prototype. Accordingly, the task in this chapter is to map the knowledge acquired by interviewing counselors and consulting guidelines, specifically that of pre-test counseling, into trees that depict the decision making process in VCT.

4.3.1. Pre Test Counseling

The five variables involved in pre-test counseling are:

- Exposure to risk
- Pattern of risk
- Risk triggers, vulnerabilities and circumstances
- Risk reduction
- Preparation for test

Each of these variables involves sub components. Generally, the counselor asks a series of questions to arrive at a certain conclusion that will enable him/her to make a final decision about a particular topic (See Annex III). The sub-components of risk exposure can be modeled as follows. First the client is asked question that will enable the counselor to determine the client's exposure to risk, following by queries that will assist in rating the risk pattern of the client.

Exploring options to reducing risk generally involves a series of questions relating to a client's sexual activities particularly within the past six months. After reviewing risk

reduction attempts, the counselor proceeds to identify successful experiences with practicing safer sex. In this parameter, the goal in each direction is to identify any obstacles the client has had in reducing risk. If s/he has been practicing safe sex, well and good. If not, then the challenge should be identified and discussed as a next factor.

In order to place risk behavior in the large context of the client's life, the client is asked about the times in his/her life when s/he felt like it has been more challenging to practice safe sex and protect him/herself from HIV. If the client answers with an affirmative, then s/he is provided with possible emotional states that have put them in a difficult position with respect to practicing safer sex. Some of these are: unemployment, mental depression, end of a relationship, etc. If there had been no such incidents, the counselor simply skips to assessing condom skills.

During the Knowledge acquisition phase, counselors selected for the study were interviewed to understand the process and stages of HIV pretest counseling. The interviews were open-ended and non-structured so as to understand the decision making process in HIV pretest counseling. Secondary source of information were the published data available at health institutions and HIV/AIDS organizations, such as CDC, UNAIDS, WHO, etc.

From the existing HIV pretest counseling process, the following 5 major classifications of variables are considered in the evaluation process.

- Exposure to risk
- Risk Pattern
- Risk triggers, vulnerabilities and circumstances
- Risk reduction
- HIV test preparation

The above five can be termed as primary nodes and further divided into secondary nodes as follows:

- Primary node 1: Exposure to risk: 'high', 'low'

  Secondary nodes:

  - Level of concern, values high or low
  - Risk Behavior, values yes or no
  - Indicators of increased risk, values yes or no
  - Risk reduction attempts, values yes or no
  - Partner's risk, values yes or no

A client's past sexual behavior indicates whether or not he/she have had a major (classified herein as 'high') or minimal (classified as 'low') exposure to HIV. The level of exposure to risk (high or low) can only be identified after gathering information from the client himself/ herself, through a series of questions, about:

- The level of concern they have about having acquired HIV from someone or though some other experience. For instance, the counselor asks the client "Do you have any concerns about having acquired HIV?" and the person will give response based on their own sexual behavior, or other experiences that may have exposed them to HIV. Clients who can think of incidents that may have put them at risk express a high concern about risk exposure, while those with no or less risky exposures indicate that they have very low concern about acquiring the virus.
- Similarly, the counselor also attempts to find out from the discussion with his/her client whether or not (values yes or no) the client has had any risky behavior, whether or not (values yes or no) there are any indicators of an increased risk of exposing

oneself to HIV, if any risk reduction attempts have been made (values yes or no) and if the client's partner has any risk of acquiring HIV (values yes or no).

- The "values" generally imply the answer to be given by the client to each question under a specific topic. The reply the client gives to each question is then analyzed by the counselor to enable him/ her come to a basic understanding with regards to the client's high or low exposure to risk.
- All of the above can be depicted using the decision tree in figure 4.4.1a given below.

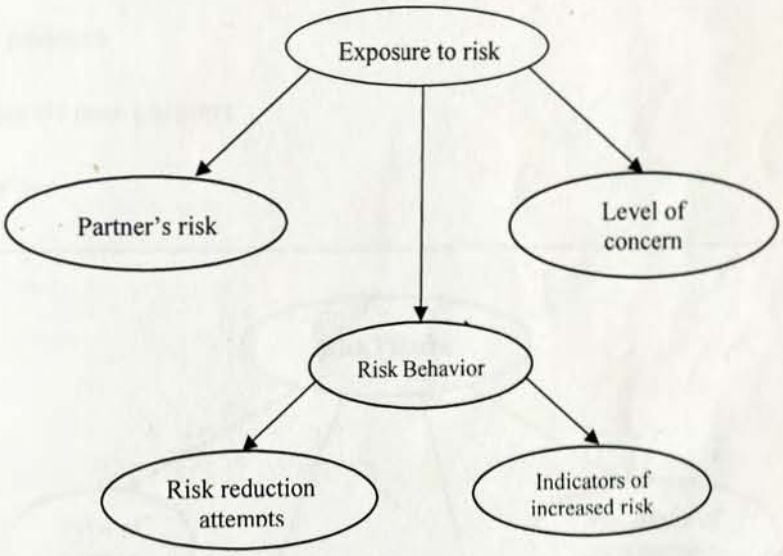


Figure 4.4.1a Risk Exposure

- In the above decision tree, the value of the node "risk behavior" is determined by the combined value of the two lowest nodes "risk reduction attempts" and "indicators of increased risk". This is simply because the counselor first finds out whether or not a client has made any attempts to reduce his/her risk (such as through abstinence and using condoms) and if there are any indicators of increased risk (such as having a partner who makes it difficult to negotiate safe sex) before proceeding to examine other risk behaviors.

- Similarly, the value of the primary node "risk exposure" is determined by a combination of the responses the client gives to their partner's risk, their personal level of concern regarding HIV, and the response already given to their risky behaviors in the past.
- The same logic applies in explaining the nodes in the decision trees given below.

o Primary node 2: Risk Pattern: 'Irregular', 'Regular'

Secondary nodes:

- Number of Partners
- Type of partners
- Frequency of new partners
- Condom use

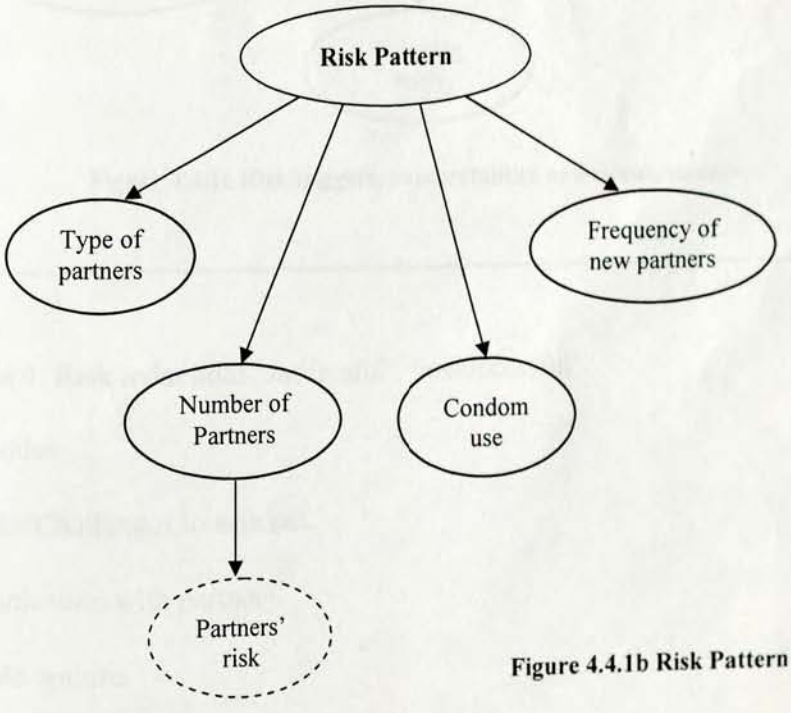


Figure 4.4.1b Risk Pattern

- Primary node 3: Risk triggers, vulnerabilities and circumstances: 'vulnerable', 'not vulnerable'

  Secondary nodes:

  - Drinking habit
  - Attitude towards sex
  - Awareness about STDs and HIV/AIDS

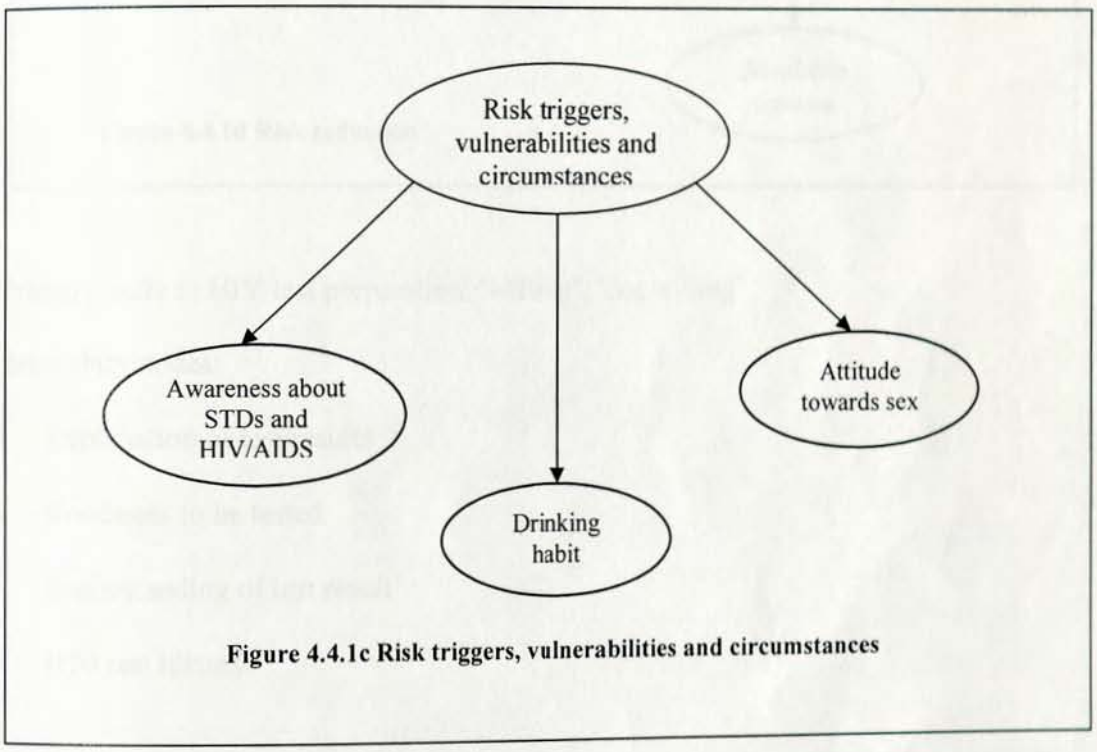


Figure 4.4.1c Risk triggers, vulnerabilities and circumstances

- Primary node 4: Risk reduction: 'successful', 'unsuccessful'

  Secondary nodes:

  - Obstacles/Challenges to safe sex
  - Communication with partner
  - Available options

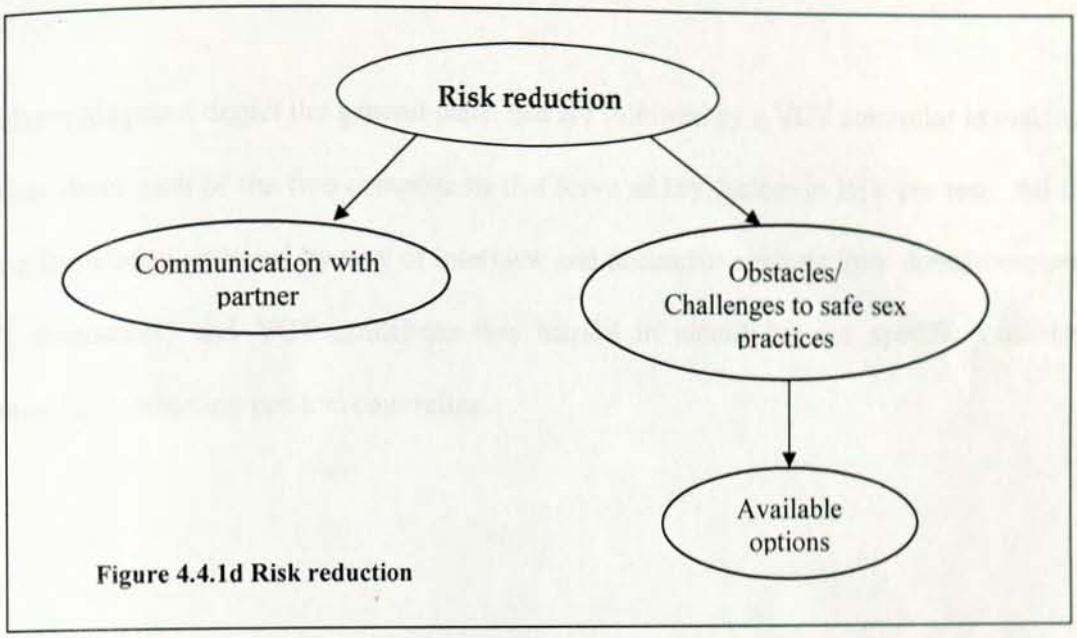


Figure 4.4.1d Risk reduction

- Primary node 5: HIV test preparation: 'willing', 'not willing'

  Secondary nodes:

  - Explanation of test results
  - Readiness to be tested
  - Understanding of test result
  - HIV test history

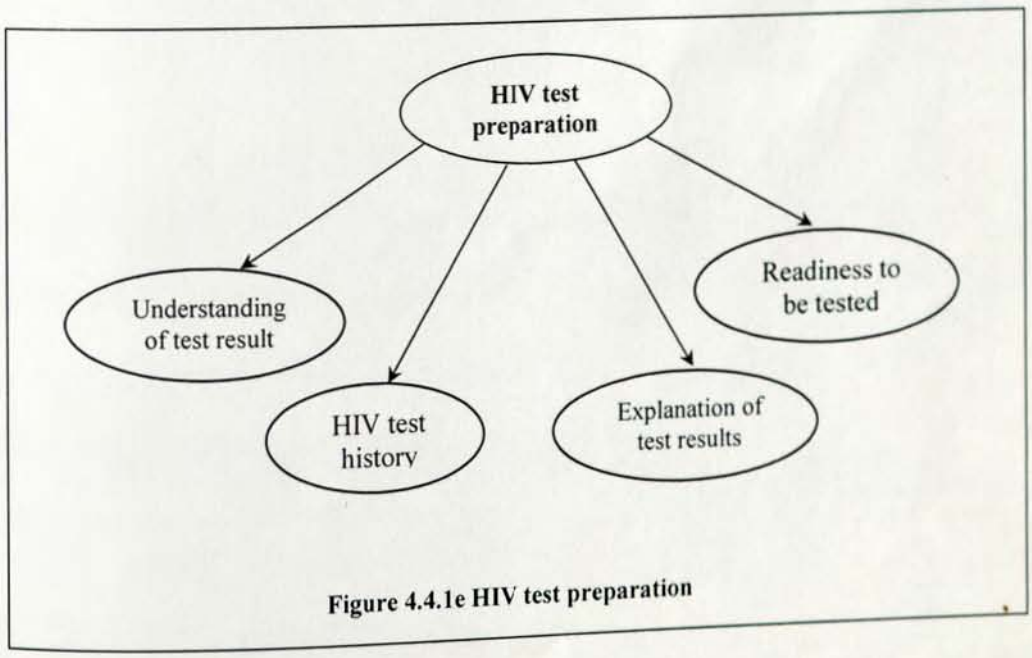


Figure 4.4.1e HIV test preparation

The above diagrams depict the general paths that are followed by a VCT counselor in making decision about each of the five components that serve as key factors in HIV pre-test. All in all, the knowledge gathered by way of interview and document analysis from domain experts (VCT counselors) and VCT guidelines was helpful in identifying the specific variables essential for conducting pre-test counseling.

CHAPTER FIVE

KNOWLEDGE REPRESENTATION

5.1. INTRODUCTION

Knowledge representation is generally a method of "storing and processing knowledge in computers" (Aroyo, 2006). As described in the literature review chapter, knowledge-representation involves the process of framing rules and developing a rule base, which enables the system to apply knowledge for decision making. This involves the challenging task of mapping a typical dialogue between a counselor and a client into a knowledge base, the details of which are explained in the following sections of this chapter.

5.2. GOALS

- In order to determine the rules to be contained into the knowledge-base, it is first essential to identify what goals the system should aspire to achieve. This is generally the task of assigning, or in other words, telling the system what task it should perform and how.
- Primary areas: The system being goal driven, strives to reach a goal, which is, all the variables rendered with values on a two point scale of 'Risky' or 'Non-risky'. This goal in turn leads to the 'plan' or 'test' decision. If we consider all the 5 variables in pre-test counseling (i.e. Exposure to risk, Pattern of risk, Risk triggers, vulnerabilities and circumstances, Risk reduction and preparation for test) and their total 17 subcomponents, their combinatory rating with the above scales (risky and non-risky) makes a total of 76 goals. This particularly becomes challenging for designing the system. Hence,

preparation for test is reduced from the primary areas due to the fact that it can be treated independently without affecting the other four variables

- Possible goals derived by combining the five primary areas: the goals decide whether the user is ready to be tested for HIV ('test' decision) or if guidance should be given to plan a test at a later date ('plan' decision).
- The list of possible goals that can be reached using a combination of the variables, Exposure to risk, Pattern of risk, Risk triggers, vulnerabilities and circumstances, Risk reduction, and Preparation for test are depicted are given below as ER, PR, TVC, RR and PT respectively.

    - Goal 1: (ER,PR,TVC,RR): All Risky
    - Goal 2: (ER,PR,TVC,RR): All non-risky
    - Goal 3: (RR): Risky, (ER,TVC,PR): Non-risky
    - Goal 4: (RR): Non-Risky, (ER,TVC,PR): Risky
    - Goal 5: (ER): Risky, (PR,TVC,RR): Non-risky
    - Goal 6: (ER): Non-Risky, (PR,TVC,RR): Risky
    - Goal 7: (PR): Risky, (ER,TVC,RR): Non-risky
    - Goal 8: (PR): Non-Risky, (ER,TVC,RR): Risky
    - Goal 9: (TVC): Risky, (ER,PR,RR): Non-risky
    - Goal 10: (TVC): Non-Risky, (ER,PR,RR): Risky
    - Goal 11: (ER,PR): Risky, (TVC,RR): Non-risky
    - Goal 12: (ER,PR): Non-Risky, (TVC,RR): Risky
    - Goal 13: (ER,TVC): Risky, (PR,RR): Non-risky
    - Goal 14: (ER,TVC): Non-Risky, (PR,RR): Risky
    - Goal 15: (ER,RR): Risky, (TVC,PR): Non-risky
    - Goal 16: (ER,RR): Non-Risky, (TVC,PR): Risky

A non-risky decision can only be reached if all the factors under consideration have a non-risky result. Therefore, of the 12 goals above, only goals 2, 3 and 9 show that the user has non-risky sexual behavior, while the other goals indicate a risky behavior. For instance, if goal 2 is reached after going through all 5 variables of pre-test counseling, the client is informed that he/she has a non-risky behavior and is encouraged to test as the only way to confirm their HIV status. The decision of whether or not to test for HIV rests with the client, not the counselor. Thus, if the client decides to test after learning that s/he has a 'risky' or 'non-risky' behavior, then the counselor will take the 'test' decision. Otherwise, the 'plan' decision is taken. The test decision will prepare the client for test before actually proceeding to test, with an invitation to return back to the counselor afterwards for receiving posttest counseling. The plan decision will advice the client on how to protect him/herself from the virus until they are ready to take the test and know their HIV status.

5.3. THE KNOWLEDGE BASE

The knowledge base of VCE-AIDS stores knowledge in the form of a set of IF-THEN rules, which makes it a rule-based expert system. KPWin has an in-built inference engine that is capable of reasoning with both the expert knowledge it contains and the user-specific data to a particular problem being solved such as risk reduction in pre-test counseling.

Rules are basically 'if...then' statements that take an action or actions only if a certain set of conditions are met. KPWin requires rules to be placed under topics. Topics contain commands that need to be evaluated before arriving at a certain conclusion or specifies actions associated with a value/input given by the user. In this regard, the VCE-AIDS database contains partial conclusions based on case specific data to be provided by the user.

For instance, the following sample topics contain partial conclusions (to the final conclusion that the client has high/low exposure to the risk of HIV):

```
if ?'level of concern' is yes
and ?'risk behavior' is yes
and ?'increased risk indicators' is no
and ?'risk reduction attempts' is yes
and ?'risk of partner' is yes
then RiskExposure is high

.

if ?'level of concern' is yes
and ?'risk behavior' is yes
and ?'increased risk indicators' is no
and ?'risk reduction attempts' is yes
and ?'risk of partner' is no
then RiskExposure is low.
```

The knowledge base uses the above format for representing knowledge, using:

- Question marks: to indicate the value of variables. For instance, the syntax ?'level of concern' has the same meaning as "the value of the variable 'level of concern'".
- The "is" operator: which is used to assign the variable in the right hand (such as "no/yes") to variables in the left hand side (such as "risk behaviour").
- Single quotes (''): used to bound terms with more than one word.

5.4. SYSTEM'S CONTROL STRUCTURE

VCE-AIDS has used the built-in backward chaining features of KPWin to build the rule-based prototype application. Thus, backward chaining occurs automatically when a search for the value of a topic locates a topic but the topic has not been assigned a value. For example, in the execution of the topic RiskExposure given below, the main topic (RiskExposure) is temporarily suspended and the search topic (eg. 'level of concern') is immediately executed.

```
Topic RiskExposure.
        if 'level of concern' is yes
        and 'risk behavior' is yes
        and 'increased risk indicators' is no
        and 'risk reduction attempts' is yes
        and 'risk of partner' is yes
        then RiskExposure is high.
End.
```

This is done so that the value of the topic can be determined as it executes. The topic executes until the maximum legal number of values (eg. 'level of concern', 'risk behavior', 'increased risk indicators', 'risk reduction attempts', and 'risk of partner') has been assigned to it, all its commands are executed, or a command that stops an execution of application.

5.5. THE EXPLANATION FACILITY

The two important explanation factors in an expert system are the ability to explain how the system arrives at a certain conclusion, and why the user is being asked a particular question. In light of this, VCE-AIDS handles these two issues using the "HOW" and "WHY" features of KPWin 3.0 as per the following examples.

The WHY facility: For every question asked by VCE-AIDS, the system is endowed with the capacity to give explanation to the relevance of that specific question to the topic being dealt with. A typical example from VCE-AIDS is given below.

Question: "Do you have multiple sexual partners?"

User input: "Why?" (Which is to mean "why am I being asked this question?")

Explanation: "Because having sexual relationship with more than one partner increases your chance of acquiring HIV from one among the many partners, particularly if those sexual partners also have more than one relationships."

The HOW facility: VCE-AIDS also has a facility that is capable of explaining how it was able to arrive at a certain conclusion. If it was, for example, able to determine that a client has high exposure to HIV risk, then it will explain the possible factors that led the system to conclude that the client has a high risk.

A practical example of the HOW facility in VCE-AIDS is given as follows:

VCE-AIDS output: "The information you have shared with me so far indicates that you have a high exposure to risk."

User input: "How?" (Meaning "How did you arrive at this conclusion.")

VCE-AIDS output: "Because you have concern about having HIV, risky sexual behavior in the past (drinking, unprotected sex, multiple sexual partners), and increased risk from your health history (TB)".

5.6. REPORTING FACILITY

As no physical record of a client is maintained when s/he undergoes an HIV counseling, the only way a user can refer back to information that has been discussed with the counselor is to get a written list of recommendation from the counselor. This procedure is handled by VCE-AIDS through a report generation feature, which allows the user to keep a printed copy of the important discussion points during the session.

Users can benefit from this feature only if they wish to use the information for later or ongoing reference. This is done so following a standard reporting format developed for the purpose, which has the capacity to give the user the necessary information on:

- The decision that was made by the system
- How that conclusion was reached
- A specific plan (depending on whether they are high or low risk).

This option is made available to the user at the end of the pretest session using a single click on the "Print Report" button.

5.7. CONFIDENCE FACTOR

Basically, lack of confidence means that the system should either explain the question to the user (using such means as hypertext and multimedia), or ask a more precise question. Another way of handling confidence is the traditional way, whereby numbers are manipulated by performing mathematical calculations as needed to obtain a total confidence factor.

In VCE-AIDS, uncertainty is handled by an explanation factor. Therefore, it essentially uses explanation as a more practical means of handling uncertainty rather than assigning a numerical value that measures the level of confidence about a response given to a particular question. The reason for this is has to do with the very fact that a successful consultation needs to involve precise questions that allow clients to be certain about the answer they give.

In such instances, it would be more appropriate to clearly explain the question and allow further explanation to be made about meaning of questions instead of asking users to determine how sure they are about their answer using percentages.

For instance, VCE-AIDS asks the client the general question "Have you put yourself at risk for HIV recently?" and the options of answers given may be 'yes' or 'no'. The client is then asked more questions that prove the validity of the answer s/he has given to the question. If the client does not think that they have put themselves at risk for HIV but later answer 'yes' to a question "Have you ever had unprotected sex?", the inference system would identify the contradiction in the client's response and concludes that the client has put him/herself at risk despite their opinion otherwise.

All in all, the VCE-AIDS prototype knowledge-base contains a total of 39 topics (15 major and 24 sub-topics) under which, there are about 48 rules in risk exploration session of the pre-test counseling. A sample of the rules is attached as an annex (see Annex V).

a human counselor. Figure 6.1.2 below gives an example of both types of interactions with the user.

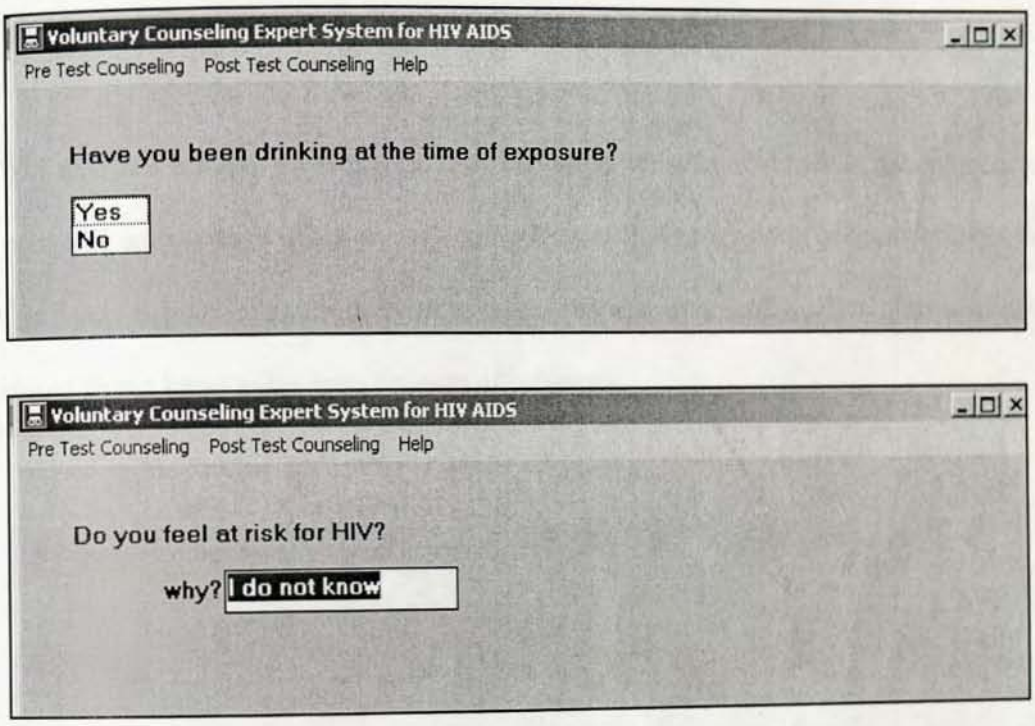


Figure 6.1.2 Inputs from user

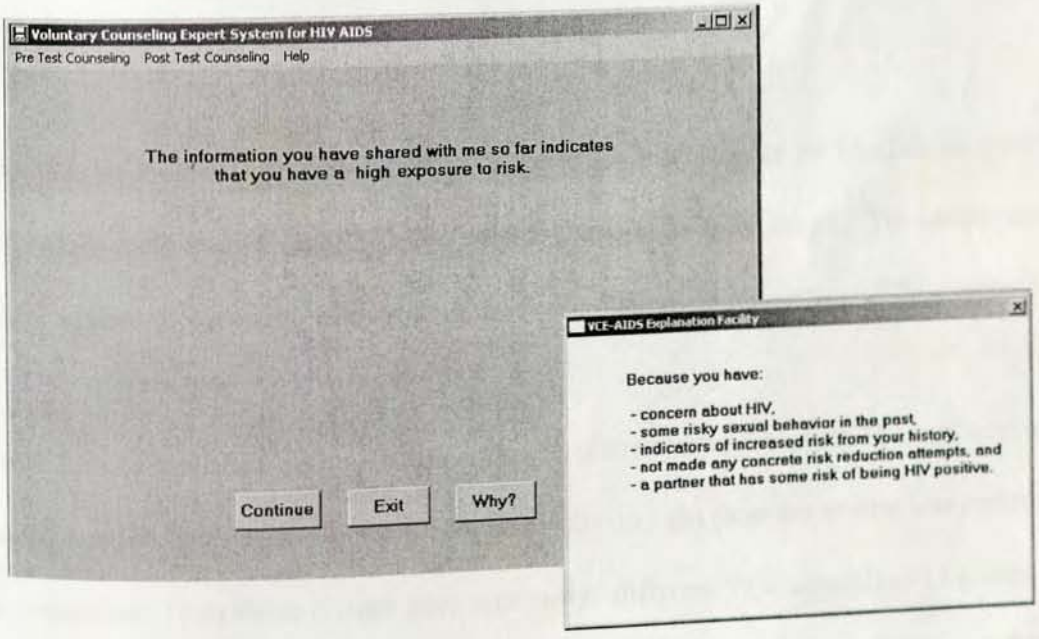


Figure 6.1.3 Final decision and explanation.

Once conclusion is reached about a specific topic, the user is given an opportunity to go over the discussion held with the system by undertaking the session again if s/he wishes to do so. If not, the next topic in pre-test counseling will be covered until the user decides whether or not they are ready to be tested.

VCE-AIDS also has a menu whereby the user can select whether they would like to receive pre- or post test counseling. Each menu contains the different sessions in each protocol as depicted in figure 6.1.5. Information such as where the user may seek medical treatment can also be stored in the knowledge base for ease of reference.

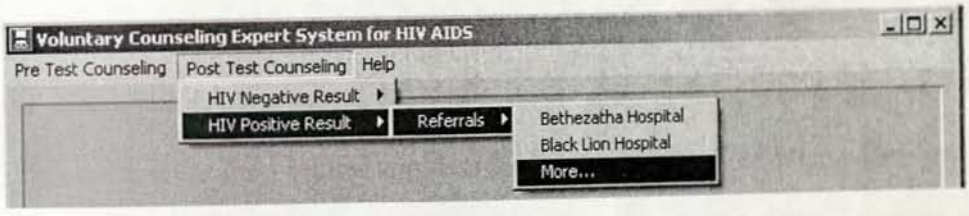


Figure 6.1.5 Toolbars for VCT protocols

6.2. TESTING

The modules of VCE-AIDS, risk exposure, is tested for performance on 15 different people and the results have shown an 86.6% accuracy in drawing its conclusions. The results were compared against the decision trees used in the conceptual modeling section of this research.

The procedure followed in testing for the accuracy of the system was, first 15 users received voluntary counseling using VCE-AIDS and the results they got from the system was recorded by the researcher. Then those clients were sent to five different VCT counselors (3 clients to one Counselor) and the result they got during their pre-test counseling session was compared against the output of VCE-AIDS. In the result, 13 out of the 15 clients counseled using VCE-

AIDS achieved the same result as a human counselor in terms of determining whether or not they have had high or low exposure to HIV/AIDS. The details of the testing process are attached as Annex VI.

Furthermore, three VCT counselors from JHPIEGO, a John Hopkins University affiliated organization in Ethiopia and Center for Disease Control have given a written comment on the prototype and the objective around which the system is developed. The evaluation by the domain experts is annexed. (See Annex VI)

6.3. KNOWLEDGE BASE MAINTENANCE

The expert system prototype has a knowledge base editor that can be used to easily update and/or check the knowledge base. Each topic in the knowledge base is supported by a comment that explains the rule so that any knowledge engineer can understand the way the knowledge base is built for future modification. The rules in the VCE-AIDS knowledge base editor follow the sequence of decision trees for logical reference.

KPWin allows for easy importation of rules to its editor using a single "include" command. Expansion, modification, and/or upgrade of the knowledge base can be handled through:

- Centralized system if an online version of VCE-AIDS is launched.
- Issuing upgrading CDs periodically to users who are using the expert system
- Training individuals who will be responsible for the above tasks in absence of a knowledge-engineer familiar with the technical aspects of the system
- Issuing trouble-shooting manuals
- Providing email/online assistance as needed.

6.4. SYSTEM REQUIREMENTS AND FUTURE APPLICATION

The prototype was developed using a computer with a Pentium IV CPU, 1.60 GHz, and 128 MB of RAM. However, the minimum system requirement for running VCE-AIDS on stand alone computers is Windows 3.0 Operating System, and 2 MB Memory. The software requirement is limited to Knowledge pro gold version 3.0 or above.

Moreover, the transformation of VCE-AIDS from a prototype to a full-scale application will require the following, among other things:

- An expert system shell that can handle consultation/dialogue between user and system more easily and which is preferably KPWin compatible so that the already-existing rules can be imported to the new shell;
- Financial resource for purchasing this new shell;
- A considerable amount of time for mapping all knowledge acquired from a human HIV/AIDS counselor into a knowledge-base;
- Closer collaboration with VCT counselors until a satisfactory result of the final application is obtained by applying a series of testing and evaluation procedures.

CHAPTER SEVEN

CONCLUSIONS AND RECOMMENDATIONS

7.1. SUMMARY

Ethiopia's poverty stricken economy is burdened with yet another cross-sectoral problem as the HIV/AIDS pandemic claims the lives of its working force and stands as a threat to many more. From individual to society and national to international, efforts are underway to take a step in the direction of preventing further infections and provide the required moral, financial and medical assistance to those men, women and children who are already living with the virus.

Considering the number of lives that are currently affected, directly or otherwise, by the HIV epidemic, prevention methods like Voluntary Counseling and Testing are still in their infancy in terms of application efficiency – especially in such developing nations as Ethiopia. Many economic, social, cultural, and religious factors contribute to the performance of VCT in playing its role as an effective tool for preventing the spread of the disease. In such instances, the importance of testing for HIV lies in decreasing the amount of stigma associated with the HIV test. And a person can make an informed decision about whether or not to be tested for HIV, even though one may not be sick from the virus, only when they undergo Voluntary Counseling.

Thus, one of the effective means by which the spread of the disease can be significantly reduced is through detail information sharing on the mode of HIV transmission and methods of prevention. In this regard, Voluntary Counseling and Testing has been and is still being implemented throughout the country as preventive tool. The challenges that are associated

with providing and/or using counseling services still calls for a greater need to plan towards better ways of making VCT accessible to and frequented by majority of the over 70 million population residing both in rural and urban areas.

Despite its importance, however, the prevailing stigma and taboo against open discussion about sex have hindered people from freely utilizing VCT services to the level desired. This research is, therefore, a contribution that viewed the problem from a different perspective, i.e. the possibility of providing or receiving counseling on HIV/AIDS using an expert system.

7.2. CHALLENGES AND OPPORTUNITIES

During the design and development of the prototype knowledge-base system for HIV/AIDS counseling service, the researcher was able to identify the following challenges and opportunities in applying the expert system technology to VCT.

7.1.1. Challenges

- Addressing the emotional aspects of counseling is challenging, if not impossible, for a non-human HIV counselor.
- The details involved in voluntary counseling make the task of designing rules a complicated (nonetheless achievable) process, which requires a lot of time to exhaust possibilities. Designing the rule for a single node in a decision tree may take an average of 45 rules and more. A full-fledged system, therefore, requires hundreds of rules to be developed and linked.
- Language barrier to design a system that can conduct the consultation in the Amharic or other Ethiopic languages.

7.1.2. Opportunities

- VCE-AIDS should not be thought of as an academic exercise alone. The prototype is only a trial version to a program that can fulfill the objectives it set out to achieve.
- Given financial and time resources, VCE-AIDS has the opportunity to grow into a popular counseling system that particularly interests the youth.
- Designing an expert system for counseling individuals is a challenging area that opens up a wide arena for experimenting on how to refine the design and development process.

7.3. CONCLUSIONS

The primary objective of this thesis is to look into the feasibility of employing the expert system technology to the area of VCT counseling. Towards this end, a prototype was developed on the area of pre-test counseling using the KnowledgePro Gold expert system shell. The resulting system, VCE-AIDS, is built as first step in the on-going process of refining the task of using such technologies to such areas as VCT.

All in all, the thesis work was able to demonstrate that the capabilities exist to build a complete pre- and post-test counseling system using the knowledge-based system development techniques. The output of the system, with the necessary modifications and update, would serve to tap the following advantages:

- The expert system, unlike some human counselors, does not have a judgmental attitude towards those receiving counseling on their personal sexual behaviors;
- Introduces users to the type of discussions held in an actual VCT session and thus serves to remove the prejudice and fear people have towards receiving counseling;
- Its modern approach is a more youth-friendly counseling technique;

- Allows an honest and unreserved information sharing by the user, which would have been difficult to discuss freely with a human counselor;
- Provides an easy access to information on where and how to seek medical, preventive and psycho-social services; and
- Enables a considerable number of people to take counseling at the same time.

Moreover, the prototype has been able to demonstrate the applicability of the expert system technology to the area of Voluntary Counseling and Testing at a satisfactory level. More research on the area can also reveal a more polished version, that will eventually develop VCE-AIDS into a full fledged system.

7.4. RECOMMENDATIONS

- Develop a system for posttest counseling so that it can be integrated with VCE-AIDS to become a complete counseling system;
- Conduct a comprehensive research on the challenges and opportunities associated with applying the expert system technology to Voluntary HIV/AIDS counseling;
- In order to solve the language barrier, refine the system using motion video features in KPWin or other expert system shells;
- Develop specialized expert systems for different areas of HIV/AIDS such as Prevention of Mother to Child Transmission (PMTCT);
- For post test counseling, establish a "coded system" whereby the system can distinguish the result of the user. This code can then be provided on the laboratory result paper, which the user will enter to know his/her serostatus. The laboratory result will only contain a combination of codes that the system will internally identify as negative or positive so that the user can receive the appropriate counseling;

- Investigate the possibility of summarizing the text input by users during consultation;
- Incorporate a self-learning facility that will allow the system to add more rules to its knowledge-base whenever it is faced with a decision that is not incorporated in the original design; and
- Experiment with the results that will be achieved by applying a different expert system shell to designing a counseling system for HIV/AIDS in order to tap the advantages of shells exclusively designed for managing expert systems for giving counseling.

ANNEX I

Prominent HIV/AIDS Organizations in Ethiopia

1. Actionaid Ethiopia
2. African AIDS Initiative International
3. Afar Mothers and Child Care Organization
4. Aids Resource Centre
5. Care Ethiopia
6. Centro Volontari Marchigiani
7. Children Aid-Ethiopia (CHAD-ET)
8. Christian Children's Fund
9. Christian Relief And Development Association (CRDA)
10. Consortium of Family Planning NGOs in Ethiopia (COFAP)
11. Dawn of Hope
12. Ethiopian Anti-AIDS Women Association
13. Family Guidance Association
14. Integrated Service for AIDS Prevention and Support (ISAPSO)
15. Mekdim HIV Positive Persons and AIDS Orphans National Association
16. The MESOB HIV/AIDS Networking Project
17. Nazreth Children's Center and Integrated Development (NACID)
18. Norwegian Church Aid
19. Organization For Social Services For Aids (OSSA)
20. Pro Pride
21. Save Your Generation Association
22. UN Theme Group on HIV/AIDS
23. UNAIDS

ANNEX II.

Number of individuals reached with community outreach HIV/AIDS prevention programs that promote Abstinence and Being Faithful	**989,700**
Number of pregnant women receiving preventing mother to child HIV transmission (PMTCT) services	**6,600**
Number of pregnant women receiving antiretroviral prophylaxis	**171**
Number of individuals receiving counseling and testing	**62,900**
Number of HIV-infected individuals who received palliative care/basic health care and support	**14,500**
Number of Orphans and Vulnerable Children (OVCs) who were served by an OVC program	**15,100**
Number of individuals receiving upstream system strengthening support for treatment[1]	**-----**
Number of individuals receiving downstream site-specific support for treatment[2]	**14,900**

Prevention and care results reflect accomplishments through September 2004. Treatment results reflect accomplishments through March 2005.

[1] Number of individuals reached through upstream systems strengthening includes those supported through contributions to national, regional, and local activities such as training, laboratory support, monitoring and evaluation, logistics and distribution systems, protocol and curriculum development.

[2] Number of individuals reached through downstream site-specific support includes those receiving services at U.S. Government sites.

Source: Global AIDS Program, the Emergency Plan in Ethiopia: http://www.cdc.gov/nchstp/od/gap/countries/ethiopia.htm

ANNEX III

Description of a Counseling Session

In pre-test counseling, risk assessment is undertaken using steps that involve a set of questions forwarded from the counselor to the client such as the reason s/he came for consultation and why they feel at risk for HIV. The counselor then asks the client to list his/her concerns about having or acquiring HIV. The counselor asks the questions "when?", "with whom?", and "under what circumstances?" to explore most recent behaviors or exposures that may have put the person at risk such as the last time clients put themselves at risk, where and when they met that person, how long they knew the person, whether they had been drinking at the time of exposure, etc.

The last four variables are used to assess a client's risk by assessing the risk of their partner. The counselor thus asks the client to share concerns regarding their partner's HIV risk, the future plans of the couple and the level of communication between the partners concerning HIV/STD risk, testing for HIV, discontinuing use of condom, and similar topics.

In terms of assessing indicators of increased risk, the counselor asks the client whether or not they have ever been diagnosed with an STD, when that diagnosis took place, if the client and his/her partner have ever been diagnosed with TB. And before proceeding to explore options for reducing risks, the counselor highlights the key issues discussed by the client in answering the questions forwarded to him/her by the counselor.

The counselor then asks the client to highlight the circumstances that had helped the individual to reduce risk when s/he was able to protect her/himself. Other issues the client needs to talk about are also brought forward for consultation at this stage.

In the HIV test preparation process, the counselor first asks the client whether s/he have been tested for HIV before, and if so, how the experience was for him/her. After listening to the past experience of the client, the counselor asks their feelings about taking the test that day.

The next question forwarded to the client by the counselor is who the client has informed about going for test and whether their partner, if any, are aware of the client's decision to know their HIV status. The counselor and his/her client then discuss about the meaning of positive and negative HIV test results and clarify any misunderstanding about the meaning of HIV test results.

The counselor and the client discuss on what test result the client is expecting and how s/he would deal with each of the possible test results. Together, they examine how the client's life will change after knowing their HIV status in terms of their behavior.

Yet another important area of consultation in this HIV test preparation part of the initial session is the issue of who will be providing the client support if s/he were infected with the HIV virus. In light of this, the counselor asks the client questions that will enable the individual to be prepared in advance for such issues as who they would tell if they were infected about HIV, who would provide them with support, and other similar matters that require psychological preparation.

After discussing on sense of optimism and well-being, the counselor and client discuss on the benefits of knowing one's serostatus (the absence or presence of antibodies for a particular antigen/virus). The counselor thus proceeds to explain how the knowledge of their HIV status, infected or not, can help to increases self-awareness and give opportunity to encourage others in the community to do the same.

The client is made aware about the fact that it is only when one knows their serostatus that they can prepare not only for their own future, but to that of their children, their partners, and others as well.

At this point, the counselor asks the client whether or not they have decided to receive HIV test in that session. In most cases, clients may have already decided that they would like to be tested that day when they come to receive the pre-test counseling. If the client expresses doubts about being tested, the counselor asks them to come back another day to be tested. In this case the counseling continues to how the client can protect him/herself and others from HIV.

Even when clients have decided to be tested, it may happen that they have not prepared themselves or their family for the possible results. In that scenario, the counselor helps in preparing the client for the results. If the client opts to be tested, the counselor proceeds to describe the tests and the interpretation of the test in the required detail.

Then in post test counseling, if the test results are negative, the first thing a counselor does in the session is to present the client with his/her HIV test results. The counselor shows the lab result papers to the client and then talks about how to best understand the negative result. The client, therefore, receives the correct interpretation of the result from the counselor.

The counselor then asks the client what the result means to them and how it feels to hear that it is very likely that they are not infected with HIV. After exploring the client's reaction to the result, the counselor reviews the meaning of the result by clarifying that negative results only mean that the individual is not infected with HIV as of more than 3 months ago. The counselor, therefore, makes a remark about the need to consider the test result in reference to most recent risk exposure.

The counselor strongly advises clients to encourage their partner (if any) to be tested. If the client has ongoing risk, the counselor conveys concerns and urgency about the risks involved by explaining to him/her that they may be infected with HIV unless their risk behavior and other issues identified in the pre-test session are addressed. This calls for a need to talk about a plan to reduce the client's risk.

In this task, the counselor and client first prioritize risk reduction behavior by identifying what the most important issues are that need to be discussed in order to help reduce his/her risk. Given what has been discussed up to this point, the counselor requests the client to share if s/he thinks there is anything that will make them put themselves at risk for STD or HIV again.

The counselor and the client then proceed to exploring behavior(s) that the client will be most motivated about or is capable of changing. At this point, the client is well aware about the options for reducing his/her risk. But the question is, which option would s/he like to use most for reducing their risk for STDs/HIV? And in order to identify a reasonable yet challenging incremental step toward changing the identified behavior, the counselor asks the client what first step s/he can think of to complete in the next week that would move him/her closer to reducing their STD/HIV risk.

Now that the client has identified what s/he would like to do, the risk reduction action is broken down into specific and concrete steps. This will help clarify how and when the options at hand can be materialized. The discussion continues to identify supports or barriers to the risk reduction step: anything that the client feels will make it more difficult and/or easier to complete this step, and how they would feel if s/he is able to complete this step. The counselor then prepares the client for handling things from getting in the way of trying their plan by specifying the possible obstacles and specific solutions.

Once again, the counselor gives the client a chance to practice how s/he could deal with the steps in the plan. This is meant to help the individual become comfortable with the plan and be ready to judge whether or not it is realistic. The counselor then tells the client that by trying out this plan, s/he would really have done something good for him/herself. Finally, the counselor writes down the complete plan on an appointment card so that the client can have a copy of the specific details of the plan.

The counselor starts by emphasizing to the client the importance of discussing with a trusted friend or relative the intention and content of the risk reduction plan. The counselor then asks the client to identify a person whom they can trust to tell about their HIV test exposure. Together, they also identify who in the client's life can provide them support so that they can avoid situations that put them at risk.

The process of identifying a person to whom the client feels comfortable in disclosing the plan begin from whoever the client has told about their visit to the VCT center that day. If not, the counselor and client continue with the process of identifying another person in the client's life who is supportive of them. If the client mentions that there is a person the client usually talks about the challenges s/he is facing, then the counselor asks whether or not the client believe they could tell that particular person about the risk reduction plan.

In order to establish a concrete and specific approach for the client to share the plan with his/her friend or relative, the counselor and client discuss on when and how the client will tell the person about the risk reduction plan. Finally, the counselor tells the client that the risk reduction plan is what the client has come up with, that it is a good plan, and that s/he has the capacity to accomplish the plan.

Once the test results are ready and the counselor learns it is positive, s/he proceeds to share the news with the client. The counselor reviews the meaning of the result to the client, clearly and simply, explaining that a positive result does not mean s/he has AIDS and that it does not indicate when the client may become ill from the virus. The counselor allows the client time to absorb the meaning of the result and informs the client that there is plenty of time to talk about the results.

After breaking the news of a positive result to the client, the counselor explores how much the client has understood the result by asking what the result means to the client and how s/he understands it. The counselor then tells the client that it is difficult to deal with the information that one is infected with HIV and finds out how the client is feeling about his/her test result. The counselor also acknowledges the challenges of dealing with an initial positive result and advises the client to take time to adjust to this, and that in time s/he will be able to cope and continue with his/her life.

A discussion on living positively is the last step of providing the positive result. The counselor simply provides pamphlets to clients who are not prepared for this discussion. The counselor informs the client that there are many people who are infected with the virus and living well and asks him/her if they know anyone who is living in that condition. The consultation on positive living revolves around: what it means, what it involves, and what the client can do to live positively.

To better prepare the client to sharing their test result with another person, the client is asked to predict the reaction of the person and what they would say to them. After identifying a person, family member, or friend to help the client through the process of dealing with HIV, the counselor makes the client aware to the fact that there are a lot of issues that should be

addressed over time. Some of these issues are: coping and support, planning for the future, positive living and medical follow-up.

The counselor then identifies current health care sources available to the client by asking such question as where the client goes when they need medical attention, when it was that they received their last medical care, and how difficult it is for them to access care due to lack of transportation, resources, etc.

The counselor and the client then discuss about situations in which the client may want to consider protecting his/her own confidentiality, such as informing employers about being HIV positive. Options of support groups (posttest club) are also discussed to let the client know that there is support available if s/he is interested in talking with others in his/her situation.

As a last discussion point in identifying sources of support, the counselor provides the client with the appropriate referrals including the name and phone number of the person they should call to get assistance with the issues discussed. The potential obstacle to getting the support or services the client needs are also discussed between the client and counselor.

In the next segment of the post-test counseling, the counselor explores his/her client's feelings about telling their partners about their HIV positive test result. Discussion is held on concerns, if any, about sharing the news of a positive result with client's partner(s).

Once again, the counselor reminds the client that their result does not indicate the partner's HIV status. The counselor helps the client to understand the probability that a partner may not yet be infected by the virus. The client is then asked to identify partners whom s/he feels should know about the positive result so that they can be informed of their risk for HIV

infection. Possible approaches to disclosure of serostatus to partners and whether the options are difficult for the client are also raised and discussed.

The client then anticipates the potential reactions of their partner based on how the client and his/her partner(s) have handled difficult situations in the past. The idea of how the client and his/her partner will handle the situation if s/he is not infected is also discussed. Different approaches to disclosing the news to a partner are then rehearsed or tried out through a role-play.

The counselor acknowledges the fact that it is a challenge to deal with being HIV infected. However, the client is told that with time and support s/he will adjust and can live positively.

An assessment is also made by the counselor about the client's plan to reduce risk of transmission to current partners. The counselor tries to find out how clients plan to protect their partner(s) from acquiring HIV in order to arrive at a point where the client can be intimate and close with their partner without spreading HIV.

The risk of transmission to future partners is a matter that is explored with the client so that s/he are well prepared to protect the partner from HIV in occasions where s/he will have a new partner.

The importance of caring for oneself and the need to protect others from HIV are explained by the counselor with great emphasis. The client is encouraged to take part in preventing the spread of HIV. The important fact the counselor finally makes a client aware of is that one person, like him/her, can change the tide of the epidemic by being honest with partners and ensuring that they engage only in safe sex behaviors.

ANNEX IV

Details of pre-test counseling

INITIAL SESSION / PRE TEST COUNSELING

As the prototype to be developed is for pre-test counseling, knowledge acquired for pretest session is presented as follows through four major components:

- Introduction and orientation to the session
- Risk assessment
- Exploring risk reduction options
- Preparation for HIV

a) Introduction and orientation to the session

This session proceeds in a series of steps that involve:

- Introduction between the counselor and the client: the counselor receives, welcomes and introduces himself or herself to the client.
- Description of the counselor's role: the counselor briefly describes his/her role as a counselor.
- Explanation of confidentiality: the counselor assures the client that whatever is discussed in the session is not shared with anyone else
- Review of the rapid test process: the counselor explains the possible outcomes of an HIV test and informs the client that the test is an accurate, same day process.
- Outlining content of session: the counselor highlights the topics that will be covered during the counseling.

- Exploration of HIV/STD risks
    - Address options for risk reduction
    - Discussion of testing and meaning of results
    - Provide test and results
    - Develop risk reduction and support plan.
- Addressing immediate questions and concerns before proceeding any further.

b) Risk assessment

The important variables in the risk assessment procedure are:

- Client's level of concern about having/acquiring HIV
- Most recent risk exposure/behavior
- Client's level acceptable risk
- Pattern of risk
- Risk triggers, vulnerabilities and circumstances
- Partner's risk
- Communication between partners
- Indicators of increased risk (e.g. diagnoses with tuberculosis).

The first three variables under the risk assessment generally proceed by the counselor asking the client a set of questions such as the reason s/he came for consultation and why they feel at risk for HIV.

The pattern of risk is generally assessed by gathering information on:

- Number of partners
- Type of partners
- Frequency of new or different partners, and
- Condom use

Here again, the counselor presents the client with a series of questions in light of extracting the required facts. Some examples of the typical queries are "how many partners have you had in the last six months?", "where do you meet your partners?", "how often do you use condoms?", and so on.

The last four variables are used to assess a client's risk by assessing the risk of their partner. To point out the things that affect the client's risk behavior, the counselor discusses specific behavioral, communication, and substance use issues.

c) *Exploring options for reducing risk*

Exploring options for reducing risk is another major component of the initial session, which incorporates the following sub-components:

- **Previous risk reduction attempts**: precautions taken to protect oneself or a partner from STD/HIV are noted by the counselor in the review process, including what the client has done to try and reduce risk of acquiring HIV.
- **Successful experiences with practicing safer sex**: in this task, the counselor identifies successful experiences with practicing safer sex from specific events that the client recalls as having practiced safe sex.
- **Obstacles to risk reduction**: the counselor establishes obstacles by inquiring from the client what has been the most difficult part of reducing HIV risk.
- **Situations that increase the likelihood of high-risk behavior**: here, the counselor asks the client about particular situations or type of partners that make it difficult to negotiate safer sex.

- **Placing risk behavior in the larger context of the client's life**: the counselor asks about the times in the clients life when certain emotional states (sad feeling, being unemployed, relationship break-ups, etc.) made it more difficult to practice safer sex and protect themselves from HIV/STD.
- **Condom skills**: the counselor asks the client about:
    - How well condoms work for him/her,
    - Problems experienced with using condoms, and
    - The types of partners that make condom use most difficult.
    - If desired, the counselor will demonstrate the proper use of condom.
- **Options for reducing risk**: the counselor raises such questions as what will be easier for the client to change and what will be more difficult and why. The options for reducing the client's risk are listed on the basis of information gathered so far.
- **Role play, skill building, and problem solving**: the counselor allows the client to practice what s/he would say about wanting to reduce their risk, assuming that the counselor is their partner. Then the counselor and client switch roles, where the counselor pretends to be the client and the client is assumed to be the partner. The client will then try to respond as s/he imagines the partner will react to the idea of testing for HIV.
- **Beliefs and behaviors that are at odds or feelings that are mixed about changing behavior**: If, for instance, the client has expressed many HIV concerns but that s/he doesn't like using condoms, the counselor asks what alternatives the client presents to reduce risk. Similarly, if the client finds it important to feel free about several partners while at the same time not wanting to get HIV, then the counselor asks the client to help him/her understand this position in order to solve the contradiction.
- **Risk reduction options/discussion**: finally, the counselor lists the specific ways in which the client is comfortable in reducing his/her risk. The counselor then informs

the client that there are various choices for reducing risk. But before settling on a specific plan, the discussion is focused on the test, as the plan may change depending on the test result.

d) *HIV test preparation*

This is the last protocol component of the pre-test counseling and generally involves:

- The past
  - Client's HIV test history, and
  - Behavioral changes in response to results.
- The present
  - Client's feeling about testing for HIV
  - Who else is informed about the client's decision to come for VCT
  - Client's understanding about the meaning of HIV test results
  - Readiness for testing and receiving results
- The future
  - Who will provide the client' support if s/he were HIV infected
  - Positive living
  - Benefits of knowing one's serostratus and preparing for the future
- Prelude to testing
  - Client's test decision
  - Beliefs and behaviors that are at odds
  - Feelings that are mixed about being tested and dealing with the results
  - The tests and the interpretation/reading of the test, and
  - Instruction regarding the posttest session.

Readiness to be tested and receive the test results are then assessed based on:

- Response to positive results, and
- Response to negative results.

The VCT counselor is also responsible for discussing the concept of positive living with a client. This discussion between the counselor and client revolves around exploring the meaning of positive living from three major perspectives:

- Staying well and living longer,
- Obtaining support, and
- Follow-up medical care (such as TB prevention treatment)

Finally, the counselor directs the client to the laboratory to receive test and instructs him/her to return to the counselor in order to look at the test results together.

As we have seen, when a person takes HIV counseling, s/he is immediately exposed to many issues that will help him/her stay alert to the idea of protecting oneself and others from acquiring the virus. This is a proven and effective method of controlling the spread of HIV/AIDS because the number and depth of issues that are covered by a single HIV counseling session equip the person receiving the counseling with knowledge related to:

- The virus and how it affects the human body;
- How an HIV negative person can protect him/her self and others from HIV or Sexually Transmitted Diseases (STDs);
- Health precautions that need to be taken by HIV positive people;
- Learning to accept the fact that one is HIV-infected and planning for the future; and

Finding out what resources are available within the community to help one manage his/her HIV status, and to joining support groups.

SELECTION OF VARIABLES

Knowledge outlined in the previous sections of this chapter regarding pretest counseling on HIV/AIDS can be summarized as follows. The whole idea of a VCT is to guide the client into the future based on his/her sexual behavior in the past. This process involves identifying whether or not a client has a risky sexual behavior that increase their chance of acquiring the HIV virus.

If the past behavior of a person has put him/her in a position where s/he have already been exposed to the virus, then the task of the counselor is to help the person lead a life where they protect themselves (by making sure that they receive the right medical and emotional support) and others (present and future partners, as well as other members of their community).

If an individual has taken all necessary precautions (abstinence, proper condom use, being faithful to a single partner, etc.), and given that s/he will continue applying the same measures into the future, the counselor's role is to help that client remain unaffected by the virus. In both cases, the responsibility also extends to encouraging any existing partners to test and know their HIV status.

Throughout the counseling process, the counselor and client will exchange information on:

- Previous sexual and risk behaviors of the client
- Attitude towards sex
- Level of awareness about STDs, including HIV/AIDS
- Experiences with safe sex practices
- Number, type and frequency of partners in the past
- Level of communication and type of relationship with current partners
- Plan for protecting future partners
- Regularity and frequency of condom use
- Level of awareness and misconceptions regarding condom use
- Marriage and extra-marital affairs
- Employment and nature of work, etc.

Using these information, the counselor and clients are able to come up with a risk reduction plan that is appropriate for either a positive or negative result. Thus, the goal in the pre-test session is to assess the existence of risky behaviors in order to explore appropriate options for reducing risk while preparing the client for HIV test. The goal in the post-test session is to come up with a risk reduction plan for protecting both the HIV positive person and others from re-transmission of the virus, which involves the issues of partner referrals and identifying support for the client.

The key variables in the pre-test session can, therefore, be restructured under the following five major components and sub-components:

1. Exposure to risk (ER)
    - Level of concern
    - Risk behavior
    - Risk reduction attempts
    - Indicators of increased risk
    - Partner's risk
2. Pattern of risk (PR)
    - Number of partners
    - Type of partners
    - Frequency of new or different partners, and
    - Condom use
3. Risk triggers, vulnerabilities and circumstances (TVC)
    - Awareness about STDs and HIV/AIDS
    - Attitude towards sex, drinking habits, etc.
4. Risk reduction (RR)
    - Obstacles/ challenges: Condom skill, Behavioral change
    - Communication with partner
    - Available options
5. Preparation for test (PT)
    - HIV test history
    - Understanding of test results
    - Readiness to be tested: available support, positive living, test decision.

ANNEX V

Sample Rules from VCE-AIDS Knowledge-Base

```
topic RiskExposure.
set_number_of_values (RiskExposure,1).
use_font (?norm).

    if ?'level of concern' is yes
    and ?'risk behavior' is yes
    and ?'increased risk indicators' is yes
    then RiskExposure is high.

    if ?'level of concern' is yes
    and ?'risk behavior' is yes
    and ?'increased risk indicators' is no
    and ?'risk reduction attempts' is no
    then RiskExposure is high.

    if ?'level of concern' is yes
    and ?'risk behavior' is yes
    and ?'increased risk indicators' is no
    and ?'risk reduction attempts' is yes
    and ?'risk of partner' is yes
    then RiskExposure is high.

    if ?'level of concern' is no
    and ?'risk behavior' is yes
    and ?'increased risk indicators' is yes
    then RiskExposure is high.

    if ?'level of concern' is no
    and ?'risk behavior' is yes
    and ?'increased risk indicators' is no
    and ?'risk reduction attempts' is yes
    and ?'risk of partner' is yes
    then RiskExposure is high.

    if ?'level of concern' is no
    and ?'risk behavior' is yes
    and ?'increased risk indicators' is no
    and ?'risk reduction attempts' is no
    then RiskExposure is high.

    if ?'level of concern' is no
    and ?'risk behavior' is no
    and ?'risk of partner' is yes
```

```
then RiskExposure is high.

if ?'level of concern' is no
and ?'risk behavior' is no
and ?'risk of partner' is no
then RiskExposure is low.

if ?'level of concern' is yes
and ?'risk behavior' is yes
and ?'increased risk indicators' is no
and ?'risk reduction attempts' is yes
and ?'risk of partner' is no
then RiskExposure is low.

if ?'level of concern' is yes
and ?'risk behavior' is no
and ?'risk of partner' is no
then RiskExposure is low.

if ?'level of concern' is yes
and ?'risk behavior' is no
and ?'risk of partner' is yes
then RiskExposure is high.


        topic 'level of concern'.

                if ?concern is no
                then 'level of concern' is no
                else 'level of concern' is yes.

                        topic concern.
                        ask ('#n#n Do you feel at risk for HIV?', concern,[Yes,No]).
                        read_response ('why?',concern,'I do not know').
                        end. (*concern*)

        end. (*level of concern*)

end. (* Risk Exposure*)
```

ANNEX VI.

Results of Testing

QUESTIONS	RESPONSE BY CLIENT*														
• Do you feel at risk for HIV?	Y	N	N	N	Y	N	N	N	Y	N	N	Y	Y	N	Y
• Have you put yourself at risk for HIV recently?	Y	Y	N	Y	N	N	Y	N	N	N	Y	N	Y	N	N
• Have you been drinking at the time of exposure?	N	Y	N	N	N	N	N	Y	N	Y	N	N	Y	N	N
• Have you had sexual relationship with anyone without protecting yourself?	Y	N	N	Y	Y	N	N	Y	N	N	N	N	Y	N	N
• Have you had sexual relationship with anyone you have either met for the first time or whom you do not know for a long time?	N	Y	N	N	N	Y	N	Y	Y	Y	Y	N	Y	N	Y
• Have you or your partner been diagnosed with STD recently?	N	Y	N	N	Y	N	N	N	N	N	N	N	N	N	N
• Have you or your partner been diagnosed with TB recently?	N	N	N	Y	N	N	N	Y	N	N	N	Y	N	N	N
• Have you taken precautions to protect yourself or a partner from STD or HIV whenever you have sexual relationships?	N	N	Y	Y	N	Y	N	N	N	Y	Y	Y	N	Y	Y
• Can you think of practical measures your have taken to reduce your risk of acquiring HIV such as using condoms and so on?	Y	N	Y	Y	N	Y	Y	Y	N	Y	Y	Y	N	Y	Y
• Do you feel that your partner is at risk for HIV?	N	N	N	Y	Y	N	Y	N	Y	N	N	N	N	N	N
Decision using VCE-AIDS	H	H	L	L	H	L	H	H	H	H	L	L	H	L	L
Decision of a Human Counselor	H	H	L	H	H	L	H	H	H	L	L	L	H	L	L
Decision of Expert System Vs Human Counselor	M	M	M	D	M	M	M	M	M	D	M	M	M	M	M
Overall accuracy of the system on taking decision	Total no. of clients = 15, Total discrepancy in decision = 2, 13 out of 15=86.6%														

*Key: Y = Yes, N = No, H = High risk exposure, L = Low risk exposure, M = Matching decisions, D = Discrepancy in decision

VCE-AIDS: Testing and Evaluation format

1. How does VCE-AIDS receive a client who accessed the system for the first time to the clinic? How about a repeat client?
   - no differences
2. Are there differences in the way clients are received by the system?
   - No differences,.

3. What are the topics covered by the counseling system?
   - Risk assessment
   - Concerns about HIV.
   - Some Risk reduction
4. How does the system handle the possible reactions of the client after each topic of discussion?
   - Does not follow reactions
5. Are these reactions [of clients] necessary to go or not with the subsequent step in the pretest session? How?

-

6. How accurately does the system pass a decision about topics covered in the pretest session?
   - Good thing is that it doesn't miss risk of exposure.

7. How well does VCE-AIDS prepare a client for testing?
   - Asking serious of questions

8. How does the system confirm the understanding of the counseling process by the client?
   - I see no way of confirming but asks clear questions.

9. How is VCE-AIDS different from a VCT session conducted by a human counselor?
   - Entertains only the clients response and doesn't go to open ended discussions.

10. In your opinion, can an expert system (such as the prototype presented by VCE-AIDS) handle the task of VCT?

- If many questions from the counseling cue card are added to cover the other topics of the pretest session, the system can handle VCT services and support busy hospitals.

11. What are the limitations of VCE-AIDS?
    - Doesn't consider reactions and is not flexible.

12. What are the strengths of VCE-AIDS?
    - Save a lot of time.

Habtamu Huluqeta (MD)
PIHCT OFFICER

VCE-AIDS: TESTING AND EVALUATION FORMAT

1. How does VCE-AIDS receive a client who accessed the system for the first time to the clinic? How about a repeat client?
   - It has no differences in accepting clients who accessed for the first time or repeat

2. Are there differences in the way clients are received by the system?
   - No differences, it receives all clients the same way.

3. What are the topics covered by the counseling system?
   - Risk assessment
   - Concerns about HIV.
4. How does the system handle the possible reactions of the client after each topic of discussion?
   - The system only follows the clients response and doesn't really address the emotional component of the counseling

5. Are these reactions [of clients] necessary to go or not with the subsequent step in the pretest session? How?

6. How accurately does the system pass a decision about topics covered in the pretest session?
   - The sensitivity of getting risk exposure is pretty good, whereas the specificity need to be evaluated.

7. How well does VCE-AIDS prepare a client for testing?
   - after asking serious of questions it give the level of exposure to range from low to that of high and ask for willingness to be tested.

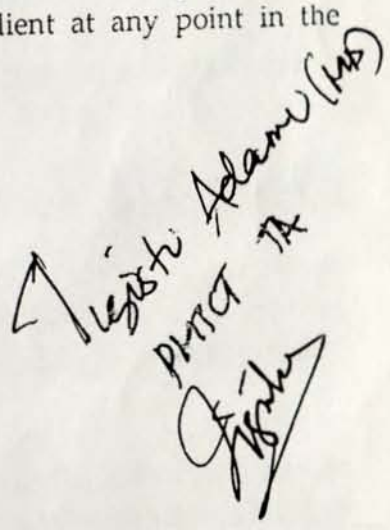
8. How does the system confirm the understanding of the counseling process by the client?
   - The only way probably is that the questions are yes and No and direct questions. And the questions are put in a simple and clear language.

9. How is VCE-AIDS different from a VCT session conducted by a human counselor?
   - The VCE-AIDS is different from a VCT session in that it doesn't take much time, client will have no concern about confidentiality,

10. In your opinion, can an expert system (such as the prototype presented by VCE-AIDS) handle the task of VCT?
   - With questions added to cover the other topics of the pretest session, the system can handle VCT services and support busy hospitals.

11. What are the limitations of VCE-AIDS?
   - The system doesn't follow the reaction of the clients and has no way of doing probing questions in cases when the client only tells part of the truth.

12. What are the strengths of VCE-AIDS?
   - It save a lot of time, the questions are clear and straight forward. And it doesn't create anxiety on the client at any point in the counseling session.



VCE-AIDS: TESTING AND EVALUATION FORMAT

1. How does VCE-AIDS receive a client who accessed the system for the first time to the clinic? How about a repeat client? There is no difference between the new and repeat client.

2. Are there differences in the way clients are received by the system? Yes there is difference by the system there is only close ended questions

3. What are the topics covered by the counseling system? Risk reduction and some test preparation.

4. How does the system handle the possible reactions of the client after each topic of discussion? There is no mechanism to handle the possible reaction of the client.

5. Are these reactions [of clients] necessary to go or not with the subsequent step in the pretest session? How?

6. How accurately does the system pass a decision about topics covered in the pretest session?

7. How well does VCE-AIDS prepare a client for testing? By asking question yes or no.

8. How does the system confirm the understanding of the counseling process by the client? It can not confirm the understanding of the client like human counseling.

9. How is VCE-AIDS different from a VCT session conducted by a human counselor? VCT session conducted by human can handle the reaction of the client but VCE can not.

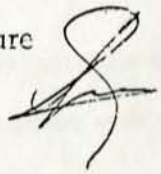
10. In your opinion, can an expert system (such as the prototype presented by VCE-AIDS) handle the task of VCT? Yes it can be handling the task of VCT if open ended questions can add.

11. What are the limitations of VCE-AIDS? It can not confirm the understanding of the client and it has no open ended questions to explore the client risk.

12. What are the strengths of VCE-AIDS? It can save time specially for those who have shortage of time and it is confidential

Name Lemlem Yeheyes

VCT Technical Officer

Signature 

ANNEX VII.

Questionnaire used for Testing VCE-AIDS

1. How does VCE-AIDS receive a client who accessed the system for the first time to the clinic? How about a repeat client?
2. Are there differences in the way clients are received by the system?
3. What are the topics covered by the counseling system?
4. How does the system handle the possible reactions of the client after each topic of discussion?
5. Are these reactions [of clients] necessary to go or not with the subsequent step in the pretest session? How?
6. How accurately does the system pass a decision about topics covered in the pretest session?
7. How well does VCE-AIDS prepare a client for testing?
8. How does the system confirm the understanding of the counseling process by the client?
9. How is VCE-AIDS different from a VCT session conducted by a human counselor?
10. In your opinion, can an expert system (such as the prototype presented by VCE-AIDS) handle the task of VCT?
11. What are the limitations of VCE-AIDS?
12. What are the strengths of VCE-AIDS?

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Declaration

I, the undersigned, declare that this thesis is my original work and has not been presented as a partial degree requirement for a degree in any other university and that all sources of materials used for the thesis have been duly acknowledged.

Redeit Alemu

March 2006

The thesis has been submitted for examination with my approval as university advisor.

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