The Use of Evaluation in the Design and Development of Interactive Medical Record Systems

by

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ABSTRACT

An explorative study was done to develop an evaluation methodology. This method can be applied during the development of interactive medical record systems in order to provide information which can be used to improve user interaction with the system.

The evaluation methodology consists of a number of interactive sessions with potential users of the interactive medical record system. During the first two sessions the subjects are trained to use the system. During the third and last session the subjects are videotaped while they are doing a set of benchmark tasks on the system under evaluation. The video recordings are analysed to obtain performance data. This performance data consists of task timings and a list of problems experienced (errors made) by the subjects. This information is subsequently used to propose a set of improvements to the evaluated system.

The systems evaluated during the study were a problem-oriented manual medical record and an interactive computerized medical record. The computerized record system was specifically developed for this study. The design and subsequent improvements to this system are documented in the study.

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CHAPTER ONE : INTRODUCTION

Although the medical record is generally recognized (Rakel 1977 p429; Barnett 1984) as an important part of the medical care process, it is extremely difficult to design an optimum medical record system. The design of such a system has to deal with a broad range of issues (Möhr 1977b), and many problems still remain to be solved. Experience has shown that the design and development of complex interactive information systems is iterative in nature (Shneiderman 1987). It is difficult to obtain an objective measure of progress in this iterative process of design and development. An evaluation methodology to establish whether any progress is made through this iteration would be a useful tool. The evaluation methodology should address fundamental issues in system usage, and relate to real world use of the system under evaluation (Roberts & Moran 1983).

In the management of patients, clinicians use a variety of information sources. The medical record of the patient is such a source of information. The medical record serves many purposes (Wingert 1981; Möhr 1977b), often in conflict with each other. A primary source of difficulty is the trade-off between the time spent by the clinician on patient care, and the time spent on documentation (Möhr 1977b). The interaction of the clinician with the medical record system is therefore of central concern (Barnett 1984; Garrett, Hammond & Stead 1986) and as such it provides a basis for the development of an evaluation methodology.

Interaction is defined as the process of direct information exchange between a user of an information system, and the system itself. The term interactive-medical-record is used in this work to indicate a type of medical record where the clinician adds information to or retrieves information from the medical record directly (without the use of an intermediary). This interaction usually happens while the clinician is attending the patient (Fitter & Cruickshank 1982). The term interactive computerized medical record system means therefore "a computerized information system that will allow a clinician to obtain direct access to a computerized version of the patient's medical record, to view, to change, or to add information to the record without the use of an intermediary".

1.1. Problem

To determine how the efficiency of user interaction with an interactive medical record system can be evaluated in order to improve the design of such a system.

1.2. Aim

The aim of this study is to explore whether an evaluation instrument based on the approach of Roberts and Moran (1983, cf. discussion in Chapter Two and Three) will be practical and useful to evaluate user interaction with interactive medical record systems. The information provided can be used to improve interaction in an iterative process of design and development, or to compare two systems in a specific case.

In order to test the methodology an interactive computerized medical record system has been developed and compared to an existing manual interactive system.

The benefits of this approach are:

a. It can establish whether the methodology is manageable in comparing medical record systems implemented in different technologies.

b. It offers the opportunity to establish whether the methodology is practical to use in the design and development cycle of an interactive medical record system.

c. It offers the opportunity to establish whether the methodology produces results that are useful for the improvement of the design of an interactive medical system.

d. Little work as been done on the evaluation of interaction with medical record systems (Garrett, Hammond & Stead 1986). This explorative study is the first step in the development of a standardized instrument for the evaluation of user interaction with medical record systems.

1.3. Limitations

a. The study is limited to interactive medical record systems as defined. It does not for example take into account systems where an intermediary such as a data-entry clerk updates the medical record. This limitation is necessary to limit the complexity of the evaluation methodology.

b. The methodology does not measure the "value" of a particular system, but is a technical measurement of system performance, and as such the methodology does not take into account broader issues such as cost–efficiency, user–acceptance and data security (Miller, Schaffner & Meisel 1985). The methodology focuses instead on aspects that will be useful for structural (detail) improvements to the system in the iterative process of design and development that is so characteristic of medical systems (see literature review).

c. The study is limited to medical record systems used in ambulatory care (outpatient) clinics or practices.

CHAPTER TWO : LITERATURE REVIEW

2.1 Medical Records

2.1.1 Purposes of Medical Records

Information is important in the process of providing health-care to a patient. The medical record of a patient is an important structure for the documentation of some of this information. "Documentation" is used to denote the acquisition and orderly storage of this information in a manner that enables retrieval according to defined criteria, as well as the presentation of this information (Möhr 1977b). The medical record serves a number of purposes (Wingert 1981 pp144-145):

a. as support for the memory of the treating physician,

b. as communication between several persons and institutions engaged in the diagnostic and therapeutic process,

c. as a document for the justification of measures taken on the basis of medical, financial or legal standards and requirements (Möhr 1977b),

d. as a device in medical education,

e. as a protocol in retrospective observational studies,

f. as a document for the management of administrative tasks.

2.1.2 Problems with Medical Records

The medical record is not without its problems. Möhr (1977b) classifies the problems as follows:

2.1.2.1 Conceptual Problems

a. The conflict between care and documentation itself, in terms of time and attention.

b. Conflicting purposes for documentation (see above).

c. Relative completeness of the record due to alternative medical models that may be applied to a particular case.

d. Subjective aspects of the documentation. The content of the medical record is influenced by the physician's reasoning.

e. The lack of standardization in the terminology applied in the medical record.

f. Medical care in modern medicine is increasingly being delivered by several health-care practitioners, with the medical record becoming the principal instrument for ensuring continuation of care (Barnett 1984).

2.1.2.2 Technical Problems

a. Amount of data.

b. Availability with respect to time and location.

c. Identification and record linkage.

d. Acquisition and presentation.

e. Quality of data.

f. Security.

g. Confidentiality.

2.1.3 Problem-Oriented Medical Records

The traditional medical record evolved in the teaching and research environment of the academic hospitals, is source-oriented and keeps the documents from each source in chronological order (Möhr 1977b). The limited value of this record in on-going patient care prompted the development of a "problem-oriented medical record" (POMR) by Lawrence Weed in 1969 (Rakel 1977). A problem is anything that requires diagnosis or management or interferes with quality of life as perceived by the patient (Rakel 1977). The POMR consists of the following components:

a. Database. The baseline information about the patient, such as history, systematic physical examination, and baseline laboratory studies.

b. Problem List. Consecutively numbered past and present problems.

c. Progress Notes. Subjective information, objective data, assessment, and diagnosis. This information is often assigned to a specific problem.

d. Plan. Treatment, investigative procedures, and patient education.

Many variations exist on the POMR as proposed by Weed. There are differences in opinion on the utility of the POMR (Feinstein 1973). Stratmann (1980) reviewed these differences

and concluded that the differences have in part been fueled by incomplete information about and the lack of objective evaluation of the POMR.

2.1.4 The Need for Improved Medical Records

The need for radically improved medical information management acted as the driving force behind the introduction of computer technology for medical record systems (Barnett 1984; Weed 1985; McDonald, Tierney & Blevins 1986). The nature of this need for improved information management has been variously expressed as follows:

a. A shift in the responsibility for ambulatory care from the solo practitioner to organized forms of group practice, with the accompanying greater need for communication and cooperation (Barnett 1984; Fitter 1986).

b. The larger volume of data collected in the course of caring for the patient. This resulted on the one hand from the multiplicity of disciplines involved in the care of the patient, and on the other from the many results from a large range of diagnostic investigations (Barnett 1984).

c. Changes in the characteristics of medical care, such as the increasing proportion of care concerned with the management of chronic disease and the greater emphasis on screening, early detection of disease and preventive medicine (Barnett 1984).

d. Reporting requirements imposed by agencies outside of medicine, such as government agencies, legal system, medical aid societies, and quality assurance programs (Barnett 1984).

e. The logistics of medical record storage, retrieval and distribution (Möhr 1977b; McDonald, Tierney & Blevins 1986).

f. Retrieval and presentation of information contained in the medical record. A computer-stored medical record can display its contents in different ways, according to the needs of the user, as opposed to the paper chart which presents data in a fixed format (McDonald, Tierney & Blevins 1986).

g. Data contained in computerized records are more amenable to analysis for answers to clinical research questions, or guides to clinical and/or administrative policy (McDonald, Tierney & Blevins 1986).

h. The conventional single copy paperbased medical record can only be used at one place at a time (Möhr 1977b).

2.1.5 Examples of Computerized Medical Record Systems

Many attempts have been made to computerize the medical record in ambulatory care. Some of the the more successful and better known are listed below (Barnett 1984; Gottinger 1984; Pryor et al 1985) :

a. Regenstrief Medical Information System (RMIS). (McDonald, Wheeler,.Glazener & Blevins 1985; McDonald, Tierney & Blevins 1986). The system is well known for its protocol-based computer reminders, described in a much quoted article by McDonald (1976). A two year randomized trial of the effects of the system is reported by McDonald, Hui & Smith et al (1984). The system is further described by McDonald, Wheeler, Glazener and Blevins (1985) with particular reference to laboratory results. In their discussion of the advantages of automated medical record systems McDonald, Tierney and Blevins (1986) noted that most of the difficulties and cost of these systems lay on the input side of the systems, and that the details of data input are often overlooked in the implementation of computerized medical record.

b. The Medical Record (TMR). (Hammond, Stead, Straube & Jelovsek 1980; Hammond & Stead 1986). This system was developed at Duke University Medical Centre over a period of eighteen years (1968-1986). The system is now being marketed commercially for use by medical clinics (Barnett 1984). The developers have introduced the concept of a "medical workstation" in which data is extracted from any available source and grouped for presentation and review (Hammond & Stead 1986). In their article on the effects of computerized medical records on provider efficiency and quality of care, Garrett, Hammond and Stead (1986) recommend that further studies be undertaken on the learning curve of interactive medical record systems.

c. Computer–Stored Ambulatory Record (COSTAR). (Barnett, Winickoff, Morgan & Zielstorff 1983; Barnett 1984; Beaman, Justice & Barnett 1979; Campbell 1986). The system was originally developed between 1968 and 1978 at the Laboratory of Computer Science of Massachusetts General Hospital. This is one of the few comprehensive medical record systems that has been commercially marketed and widely disseminated. COSTAR has been available in the public domain since 1978. In his review of the evolution of COSTAR, Campbell (1986) remarked on the limited acceptance of COSTAR given the clear superiority of computerized medical record systems compared to paper records and suggested that the answer to this question lies in the general acceptance of computers by clinicians.

e. Summary Time-Oriented Record (STOR). This system was developed at the University of California Medical Centre, San Francisco and is of particular interest because of the studies done on information transfer in this system compared to the standard medical record (Whiting-O'Keefe, Simborg, Epstein & Warger 1985).

f. The Exeter Project. The Exeter project is one of several sites set up by the UK Department of Health and Social Security in the early 1970's to explore the use of computers in the administration of patient care (Anon 1983; Clarke 1982). One of the first clinicians involved in this project later developed his own interactive system (Bradshaw-Smith 1983).

g. University of Sheffield Medical Centre. The systems developed here have been particularly well described in respect to interaction between clinician and system, and the effect of using the system on doctor-patient relationship (Brownbridge, Fitter & Sime 1984; Brownbridge, Herzmark & Wall 1985; Cruickshank 1982; Cruickshank 1985; Fitter & Cruickshank 1982; Herzmark, Brownbridge, Fitter & Evans 1984). They came to a number of important conclusions regarding computers in the consulting room (Fitter & Cruickshank 1982; Fitter 1986):

- The computer can be usefully regarded as a member of a three way relationship between patient, doctor and computer.
- The overall impact of computers on patients is small and the negative predictions are not supported by evidence.
- The main concern of doctors is the time-consuming nature of the interaction with the computer.
- Conventional human-factors research has an important contribution to make to the design of interactive medical systems, but these techniques need supplementing to take the three-way nature of the communication process in the case of interactive medical computer systems into consideration.

Work on the computerization of medical records is not restricted only to ambulatory care systems. Much of the work has first been done in the context of hospital information systems.

a. PROMIS. This is a mainframe based, computerized problem-oriented medical record system for inpatients (Walton, Holland & Wolf 1979). This system is based on old technology and not much has been published on it in recent years

(Pryor et al 1985). Barnett (1984) omits PROMIS from his list of important computerized medical record systems. However it is important in that it tried to optimize user interaction (Walton, Holland & Wolf 1979) through the use of touch-sensitive screens.

b. HELP. This is a comprehensive computer system for acquiring medical data and implementing medical decision logic that was developed at the University of Utah and LDS Hospital in Salt Lake City, Utah by Hugh Roy Warner and co-workers (Pryor, Gardner, Clayton & Warner 1983; Warner & Haug 1983).

Many other computerized medical record systems exist or are under development, the above systems are only a selection of the better known systems.

Some objective data about the benefits of computerized medical record systems are starting to appear in recent investigations:

a. Whiting O'Keefe, Simborg, Epstein and Warger (1985) have shown that for outpatient visits a computerized summary time-oriented record operationally added information to that supplied by the full paper medical record. They speculated that this improved information transfer could improve the clinical decision process.

b. Garrett, Hammond and Stead (1986) investigated the effect of computerized medical records on provider efficiency and quality of care. With the exception of prescription writing, the computerized records resulted in significant reductions in the time required for the physician to obtain data from and enter data into the record. The clinician's utilization of the recorded data was significantly better for the computerized records. Significant reduction in medication errors were also noted.

c. In a two-year randomized trial McDonald, Hui et al (1984) concluded that computer-generated reminder messages had a strong and persistent effect on patient care. The implementation of preventative care was twice as extensive among physicians in the study group than among a control group of physicians.

The above examples show that a computerized medical record system can improve the process of medical care but the effect of these systems on clinical outcome still remains to be shown. This is a difficult problem (McDonald, Hui et al 1984; Simborg 1982) to solve.

2.1.6 Limitations of Current Computerized Medical Record Systems

It is clear from Paragraph 2.1.3 that there is a need for automated processing of medical records, that several such systems are in use (Paragraph 2.1.4) and that the indications are that these systems are making a positive contribution to patient care. However, much remains to be done to improve these systems. Quoting a study done by the National Centre for Health Services Research (USA), Barnett (1984) listed the following issues that need to be addressed in the further development of the automated medical record:

a. Getting the clinician more involved in using the system.

b. Developing more efficient methods of data capture and entry.

c. Improving user interaction with the system.

This sentiment is echoed by Gottinger (1984) in his conclusion to a review of the impact of computers in medical and hospital care over the last twenty five years: "... ways must be found to make the technology more acceptable to the medical community — to lessen the magnitude of the commitment required, to reduce man/machine barriers, and to make automated systems compatible with the existing social structures".

It is clear then that much needs to be done to improve the process of interaction with an automated medical record system. This conclusion is by no means restricted to computerized medical record systems, but also applies to medical decision support systems (expert systems) (De Vries & De Vries Robbé 1985). This is a sentiment that is echoed also in other computer application fields. In their extensive review of human–computer interaction (HCI), Gaines and Shaw (1986b) make the statement that the human–computer interface is increasingly the major determinant of the success or failure of computer systems.

2.2 User Interface Design

Today HCI science and technology are widely regarded as basic concerns for computer–based system design and application (Gaines & Shaw 1986a). The requirements for a well-designed user interface are well put by Moran (1981a): "The system should help the user without getting in his way; it should be efficient to use and easy to learn; it should be consistent, logical, "natural"; amen". According to Shneiderman (1987 pp 16-18) the increased attention to human factors for interactive system design emanates from four primary sources:

a. Life–critical Systems. In these systems high reliability and effectiveness are essential. Life critical systems include air traffic control, nuclear reactor control and intensive care systems.

b. Industrial/Commercial Uses. As systems become more widespread the time to train operators increases, resulting in higher costs. Systems which are easier to learn will decrease this cost. Speed of operation is central to most of these applications because of the high volume of transactions. Medical administration systems form part of this group.

c. Office, Home, and Entertainment Applications. For these systems, ease of learning, low error rates, and subjective satisfaction are paramount. If users cannot succeed quickly they will abandon the system to try something else. Medical information systems fall partly into this group.

d. Exploratory, Creative, and Expert Systems. Computers are increasingly being used to support human intellectual and creative enterprises. Some medical record systems and medical expert systems fall into this category. In these systems the users are experts in their task domain but very often novices in the underlying computer concepts. Their motivation is high, but so are their expectations. The primary difficulty for the designer is to optimize the bandwidth between user and system. To effectively support the task of a professional, complex systems with extended functionality are often necessary. Restrictions in the user interface of such systems limit the amount of information effectively transferred between man and machine. However, this increase in functionality may lead to complex systems difficult to learn and operate.

2.2.1 Theoretical Framework.

User interface is defined as "The domain of discourse between man and machine; an interaction or series of interactions. This has hardware and software components interacting with the user, and together they compose a dialogue, both cognitive and actual, that takes place between the user and the machine, in order to convey some information i.e. a series of task requirements" (Richards, Bez, Gittins & Cooke 1986) or simply "the part of the program that determines how the user and the computer communicate" (Newman & Sproull 1979 p445). Guedj (1980 p109) in a postscript to the proceedings of a workshop (Seillac II) on the methodology of interaction, concluded that the underlying concepts in human-machine interaction have yet to emerge as discrete entities and that a methodology for designing interactive systems has yet to be convincingly advanced. This is a sentiment echoed by a number of other authors in the field (Buxton, Lamb, Sherman & Smith 1983; Draper & Norman

1985; Moran 1980). Benbasat (1981) presents a useful framework to investigate the human–computer interface. Various other frameworks have been proposed by Moran (1980), Newman & Sproull (1979 pp445-478), and Foley (1980). Models of human-computer interaction (HCI) and guide-lines for user interface design are emerging to help designers in the design of user interfaces (Shneiderman 1987).

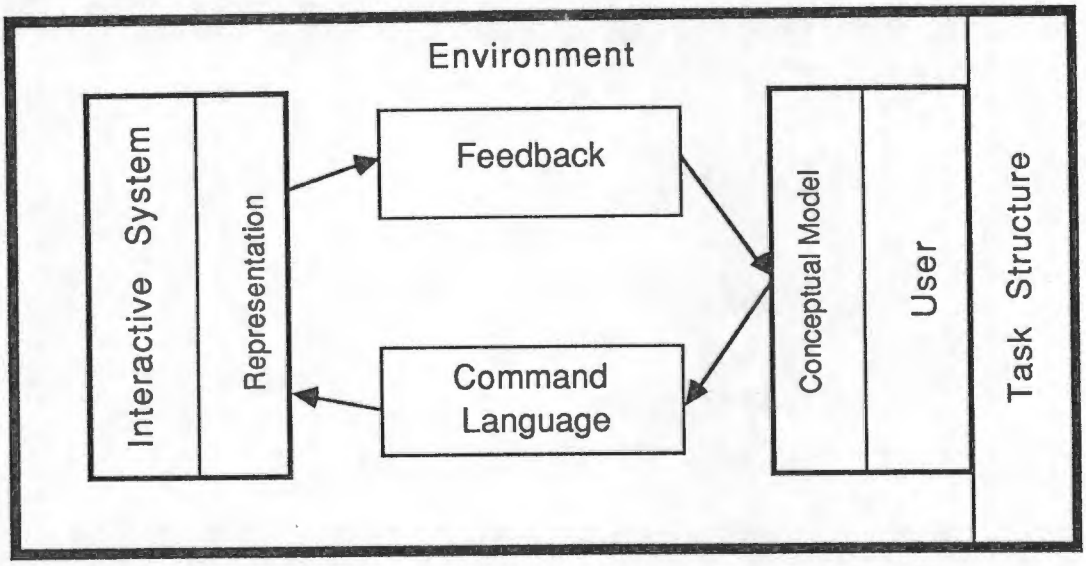

Figure 2 1: Human-Computer Interaction

Figure 2.1 represents the relationships between the various components of interest in human-computer interaction.

2.2.1.1 User Models

Most of these models describe HCI as a layered structure (Foley 1980; Moran 1980; Shneiderman 1987; Sisson 1986). Lynch & Meads (1986) reported on an extensive user interface reference model. The layers that are distinguished include the following (Foley 1980; Hoppe, Tauber & Ziegler. 1986; Shneiderman 1987):

a. Conceptual Level. This is the user's mental model of the interactive system.

b. Semantic Level. This level describes the meanings conveyed by the user's command input and the computer's output display. From the user's point of view, the important aspect is which data objects are accessible and by which functions they can be manipulated.

c. Syntax Level. The syntax level defines how the units that convey the semantics are assembled into a complete sentence. On the user's side, the input elements or tokens have to be combined according to structural rules

in order to issue a valid command to the system. On the output side the syntactical level also includes spatial and temporal factors, such as the two-dimensional organization of a display.

d. Lexical Level. Physical interaction with the system takes place at this level. This level includes issues such as naming of commands, visual representation of textual and graphical objects and the different physical devices used, ie keyboards, screen or mouse.

2.2.1.2 Design Guide-lines

A large number of qualitative principles for user interface design exist, often containing conflicting advice (Gaines 1981; Maguire 1982; Shneiderman 1979; Shneiderman 1983; Shneiderman 1987). The guide-lines followed in the design of IMIS are described in Chapter Five.

2.2.2 The Psychology of Human-Machine Interaction.

Moran (1981) states that the main contribution of an applied psychology of the user is to reliably assure satisfactory user-computer interaction. The literature supports the view that the design of an complex information system is a complex undertaking that has to deal with a diverse range of issues. Topics of interest in the psychology of HCI include:

2.2.2.1 Problem–solving and Decisionmaking

Many of the findings and hypotheses from human-interface research are explained in terms of cognitive theories and principles (Allen 1982). Rouse (1983) describes a general theory of problem-solving in which he distinguishes between two types of problem-solving — a preferred mode based on pattern-recognition and a secondary mode based on analytical or heuristic reasoning. The distinction between these types of problem-solving, also respectively known as the knowledge-based and hypothetico-deductive methods (Groen & Patel 1985), appears repeatedly in the literature on medical decisionmaking (Brooke, Rector & Sheldon 1984; Johnson 1983; Ridderikhoff 1985). It should be noted that the terms "decisionmaking" and "problem-solving" are often used interchangeably in the medical literature. Compare the article written by Groen & Patel (1985) with the articles written by Brooke, Rector & Sheldon (1984) and Ridderikhoff (1985). Problem-solving is a more general process classified by the following stages, first described by Polya (quoted in Howard 1983 p411; see also Rouse 1983), namely: recognition, classification, planning, execution and monitoring. Decisionmaking often forms a part of problem-solving, and is de-

fined by Sage(1981) as follows: "...the processes of thought and action involving an irrevocable allocation of resources that culminates in choice behavior." Simon describes the following stages in decisionmaking: Intelligence, design and choice (quoted in: Ahituv & Neumann 1982 p41). Information processing is a crucial task in effective decisionmaking (Sage 1981), and a clear understanding of problem-solving and decisionmaking is necessary (Ahituv & Neumann 1982 pp16-78; Taylor 1980) for the design of decision-support systems (DSS). Of particular interest for the design of DSS, are the various cognitive biases that can cause errors in the decisionmaking process (Sage 1981). A number of researchers have investigated cognitive biases in relation to medical decisionmaking (Balla 1980; Bergman & Pantell 1984; Leaper, Gill, Staniland, Horrocks & De Dombal; 1973; Politser 1981; Wallsten 1981; Weed 1985).

2.2.2.2 Individual Differences and Cognitive Style

Individual differences amongst the users of a system have important design implications (Zmud 1979). Areas of concern include — user sophistication (Schneider 1983), information processing strategies, and cognitive style (Ahituv & Neumann 1982 p29; Robertson 1985; Sage 1981).

2.2.2.3 Errors

The analysis of the errors that people make in the use of computer systems can assist in the derivation of design rules for user interface design (Janosky, Smith & Hildreth 1986; Norman 1983).

2.2.2.4 Information Processing / Representation

This field addresses topics such as: presentation and representation of information by the computer system to the user, the representation of control structures, and issues in the information transfer between the user and the computer system (Carroll, Thomas & Malhotra 1980; Jagodzinski 1983; Kieras & Polson 1985; Moran 1981a; Norman 1984; Oberquelle, Kupka & Maass 1983; Rasmussen 1983; Robertson 1985; Strong 1982). In their study on the effects of computerized medical records on provider efficiency and quality of care Garrett, Hammond and Stead (1986) concluded that the entire improvement in the collection of data observed in the study is due to the enhancement of the arrangement and availability of prior data. One of the aspects explored in the current study investigates whether improved representation of information (window techniques, graphics) will improve the efficiency of user interaction with the information system.

2.2.3 User Interface Design Methodology.

Concurrent with the lack of a theoretical framework for human-computer interaction, is the absence of a generally accepted methodology for user interface design (See above-mentioned references).

a. Design/Programming Rules. A large number of qualitative principles for user interface design exist, often containing conflicting advice (Gaines 1981; Maguire 1982; Shneiderman 1979; Shneiderman 1983).

b. Task Analysis. The design of the user interface should proceed from the basis of a well-defined representation of the user's task structure (Carey 1982; Dzida 1980; Eason 1980; Newman & Sproull 1979; Shneiderman 1987; Smith, Lafue, Schoen & Vestal 1984).

c. Prototyping. Various writers in the field stress the iterative nature of the user interface design process (Buxton, Lamb, Sherman & Smith 1983; Draper & Norman 1985; Shneiderman 1987; Smith, Irby, Kimball, Verplank & Harslem 1982).

d. User Interface Management Systems. An area of research receiving attention currently is the development of standardized user interface management systems (Bournique 1985; Buxton, Lamb, Sherman & Smith 1983; Coutaz 1985; Green 1985;).

2.2.3.1 Interaction Styles

Shneiderman (1987) describes a number of primary interaction styles that the designer can choose from:

a. Menu selection

b. Form fill-in

c. Command language

d. Natural language

e. Direct manipulation. In a direct manipulation interface the designer creates a visual representation of the world of action, the user can then manipulate objects of interest directly. Direct manipulation interfaces are characterized by :

- continuous representation of the objects and actions of interest,

- physical actions or labeled button presses instead of a complex syntax
- rapid incremental reversible operations whose impact on the object of interest is immediately visible.

Gaines & Shaw (1986b) distinguish three styles of interaction:

a. Formal dialogue in which the activities and data structures of the application are presented externally with minimal embellishments to aid human cognition. This corresponds to menu selection, form fill-in, and command language interaction styles in Shneiderman's (1987) classification.

b. Natural language dialogue.

c. Graphic dialogue in which the human manipulation of objects is simulated to access the activities and data structures within the application. This interaction style corresponds to direct manipulation.

These styles are not mutually exclusive, and modern applications often combine two or more of these styles (Gaines & Shaw 1986b)

2.3 Workstation Concept

The idea of a multi-functional workstation appeared very early in the history of computers. In 1945 Vannevar Bush published an article in the Atlantic Monthly, entitled "As we may think", in this article he described a device, a "memex", for individual use that would store and manipulate words and pictures (Nace 1984). JCR Licklider, an ARPA computer scientist, wrote an article in 1960 in which he proposed a new relationship between computers and people. What was needed, he wrote, was a set-up that would allow an individual to "think in interaction with a computer in the same way that you think with a colleague whose competence supplements your own" (Nace 1984). This concept of symbiosis between computer and man, or the "augmentation" of human capabilities was further developed by Douglas Engelbart, known for the design of the NLS office automation system in the late sixties and also for the invention of the "mouse" cursor positioning device (Nace 1984). The next focus of workstation development was the Xerox Palo Alto Research Centre (PARC), with people such as Alan Kay (Kay & Goldberg 1977) and Larry Tesler (1981) contributing. The work culminated in the release of the STAR workstation (Smith, Irby, Kimball & Harslem 1982). Many of these ideas were subsequently incorporated in micro-computers such as the Lisa, Macintosh (™Apple Computer), and the Amiga (™Commodore) (Williams 1983; Williams 1984; Williams, Edwards & Robinson 1985).

In the past several years, a class of computers has emerged that provides the scientific and engineering user with inexpensive personal computing power comparable with minicomputers. These machines have a sophisticated graphical user interface, combined with the capability to utilize specialized computing services, or to communicate with each other over a high speed local area network (Joy & Gage 1985). The idea of a medical workstation, as a base for an extensive medical information system, is slowly taking form (Barnett 1984; Gabrieli 1984; Sundararajan & Romensky 1985; Hammond & Stead 1986; Shea & Margulies 1985). Hammond & Stead (1986) describe the medical workstation as a place where data is extracted from any available source and grouped for presentation and review. Barnett (1984) states that such workstations will allow the physician to interact directly with the computer terminal in order to record medical information in a detailed and systematic fashion, while still providing the flexibility inherent in a narrative format. Sundararajan & Romensky (1985) provide a possible model for a comprehensive microcomputer-based system for primary health-care settings.

2.4 Evaluation.

2.4.1 Introduction

There are many dimensions of evaluation for technological systems, such as computerized medical record systems. These dimensions include: technical performance, clinical efficacy, resource cost, charges and efficacy, acceptability to the patient, physician and other users, research benefits for the future, effects on the organization of health services; and larger effects on society (Pryor et al 1985). Our interest is in the evaluation of user interaction with an interactive medical system in order to improve the design of such a system.

2.4.2 Evaluation of Computerized Medical Systems

According to Simborg (1982) at the time of a clinical decision there are four major inputs into the decision process: a) information available about the patient from the medical record system, b) information obtained directly from the patient at the time of the decision, c) the knowledge base and cognitive processes of the clinician, and d) the environment in which the clinician-patient interaction takes place. These four inputs interact in a complex and largely unknown fashion during the decision process, and can be considered the independent variables in a process which has the clinical decision as the dependent variable. The following discussions and classification is derived from Simborg (1982) :

2.4.2.1 Patient Outcome Measures.

Since the information system is one of the independent variables that affects clinical decisions and since clinical decisions, in turn, affect clinical outcomes, one could theoretically evaluate an information system by measuring its effect on clinical outcomes. Patient outcome measures have several limitations:

a. Insensitivity. Large numbers of patients and long periods of time are necessary to yield meaningful and statistically significant outcome differences.

b. Indirect. Information systems affect outcomes through the intermediary of clinical decisions, therefore it must be assumed, for evaluation purposes, that these decisions are correct and affect the outcome favourably.

c Comparison. It is difficult to quantitatively compare the various clinical outcomes that are possible.

2.4.2.2 Process Measures.

Through such measures clinical decisions are examined directly. Several approaches are possible:

2.4.2.2.1 Attribute Measures

This approach is commonly used in the evaluation of decision support systems outside of medicine (Ahituv & Neumann 1982). Typical attributes are timeliness, completeness, error rate, retrievability, user acceptance, usage rates and cost (Simborg, 1982). As pointed out by Simborg (1982) this approach has a number of advantages. It is relatively easy to apply. It can potentially provide objective and quantitative end-points. It has face validity in that it seems that a system with less errors, more complete and faster communication, etc is likely to be an improvement that is relevant to clinical care. The drawback is that the measure is inherently incomplete in that it ignores the dependent variable, namely the clinical decision. Simborg (1982) goes on to say that attribute measures are useful to understand why a system may be performing better or worse or to help determine whether costs are justified; however, they are inadequate by themselves to evaluate the efficacy of a system for influencing clinical decisions.

2.4.2.2.2 Adherence to Clinical Decision Protocols

These protocols are set up by a panel of experts and adherence to these standards is used as an evaluation measure. The main criticism of this approach is that the standards used in the evaluation are not always designed with that purpose in mind and that the evaluation only considers one aspect of clinical decisions, namely the adherence to previously defined protocols.

2.4.2.3 Generic Process Measures

Simborg defines a generic evaluation tool as a broad–based sampling of the process of care that can be used in any clinical setting and is independent of any particular intervention being applied to that process. Whiting O'Keefe and Simborg (1985) developed such a technique based on information theoretic principles. According to information theory, information is the removal of uncertainty from a system. Simborg (1982) then argued that an information system in clinical medicine has value insofar as it removes uncertainty in the clinician's ability to predict clinical outcomes of the patient. This principle was subsequently used in the development of an evaluation methodology (Whiting O'Keefe, Simborg, Epstein & Warger, 1985).

2.4.3 Evaluation of User Interaction

2.4.3.1 Introduction

In the literature on HCI probably the best known user interface evaluation methodology, is the Roberts and Moran (1983) methodology for text editor evaluation (Borenstein 1985). The following aspects of the application are evaluated:

- Expert core use.
- Errors.
- Learnability.
- Functionality.

Data for evaluation can be obtained by observing users and measuring their performance with a stopwatch (Roberts & Moran 1983); the system under investigation can log data from which usage and timing statistics can be obtained (Good 1985); users can also be videotaped (Brownbridge, Fitter & Sime 1984; Fitter & Cruickshank 1982; Herzmark, Brownbridge, Fitter & Evans 1984).

2.4.3.2 Evaluation of User Interaction in Medical Systems

In the literature on medical record systems, evaluations of user interaction are relatively scarce (Garrett, Hammond & Stead 1986).

a. In one of the earliest investigations of this type Greenes et al (1970) measured the time needed to generate progress notes with an interactive computerized system in a hypertension follow-up clinic. Notes were generated more rapidly with the system. The time needed to generate the notes declined very rapidly during the first five or six notes, and continued to decrease significantly for approximately the next five notes.

b. Fletcher (1974) compared a manual POMR with a traditional medical record. Three dependent variables were measured: time taken to read each record and to answer 10 factual questions on its content, accuracy in answering these questions, and proportion of independently determined major errors in medical care recognized in each case history after one reading. No significant differences were observed between the performance of the two records. The purpose of the evaluation was to compare the speed and accuracy with which these two formats could be audited.

c. In the Sheffield studies (Brownbridge, Fitter & Sime 1984; Brownbridge, Herzmark & Wall 1985; Cruickshank 1982; Cruickshank 1985; Fitter & Cruickshank 1982; Herzmark, Brownbridge, Fitter & Evans 1984) a number of aspects were investigated. Computer use affected the pattern of information use by the clinician, resulting in a more "formalized" consultation. Different patterns of computer use during the consultation were observed. Computer use during the consultation did not have a marked effect on the patients concerned.

d. In the study of Garrett, Hammond & Stead (TMR system) (1986) they subdivided the outpatient visit into six sequential steps. Each provider recorded the time spent in each phase of each encounter. Additional information obtained included: whether it was a follow-up visit, a complexity factor, and physician's level of training. The study was divided into three phases. The first phase lasted three months during which data was collected on the manual records alone. During the second phase timing data was collected on the use of the computer system, and it lasted for one month. The first two phases were considered to be training phases. The third phase, lasting five months, consisted of the collection of all data under a prospective randomized assignment of chart method to manual or computerized modes, stratified by provider. The computer system tested was not an interactive system, in the sense that the data was not retrieved or entered

through direct interaction with the system. The physicians received a computer printout, and data capture was done by data entry clerks after the encounter. It is not entirely clear from the article, but it seems that prescription writing was done interactively by the physicians. In the case of prescription writing the time needed for the computer mode was significantly longer than in the manual mode. However, the presence of a learning curve was demonstrated for prescription writing using the computer. This effect stabilized in the last two weeks of phase three.

2.5 Summary

The medical record is an important source of information needed in the process of providing health-care to a patient. A number of problems are experienced with medical record systems and the need for improved information management prompted the investigation of different ways of implementing the medical record. Computerized medical records appear to be a promising alternative. However, much remains to be done to realize this promise. In this respect, the improvement of interaction with the computer system is an important area of concern. Analysis of the literature outside of Medical Informatics shows that this concern is also echoed in other areas of computerization. Guide-lines for successful human-machine interface design are slowly emerging, and particular emphasis is placed on the iterative nature of the design and development process. The workstation concept embodies much of this thinking. Various approaches are used in the evaluation of medical record systems, but relatively little has been done about user interface evaluation in computerized medical record systems, in particular the application of HCI evaluation in an iterative design and development cycle. This limitation is addressed in this study.

CHAPTER THREE: METHOD AND MATERIALS

3.1 Introduction

As stated in Chapter One, a methodology is needed to evaluate the efficiency of user interaction with an interactive medical information system. The main use of such a methodology will be during the design and development cycle of a medical record system, to provide information that can be used to improve the design of the system.

3.1.1 Derivation of the Methodology

In their discussion of the aspects that an evaluation methodology for interactive systems must cover Roberts and Moran (1983) mention the following:

a. The time to perform basic tasks.

b. The error cost, or the potential that a simple error will cause data loss.

c. The learning of basic tasks by novices

d. The functionality of the system over a wide range of tasks

The underlying assumption of this methodology is that there are a set of basic tasks in a given task domain, *independent* of the technology used to support this task domain. For example in the interaction of a physician with a medical record, physicians obtain information or prescribe medications whether they are using a computerized medical record or not. This domain can be analysed and the tasks can be enumerated and structured. From this possibly large set of tasks a subset of tasks can be selected to represent a benchmark set of tasks to be used in the evaluation of systems designed to support this task domain. This set of benchmark tasks provides the basis for comparison between the systems.

The methodology described here is based on the Roberts and Moran methodology (1983; Borenstein 1985), with particular attention to points a and c mentioned above. Error cost is addressed to a lesser degree, while functionality is not addressed at all because standards as to what a medical record should contain or provide do not exist. In the limited group of medical records known as problem-oriented (POMR) guide-lines do exist, but in practice a wide variation in the implementation of these guide-lines is observed.

The task analysis described in Chapter Five (paragraph 5.5.1.3) provided the tasks structure from which the benchmark set of tasks was chosen. This set of tasks is listed in paragraph 3.2.3.1.

3.1.1.1 Differences between this Instrument and the Roberts and Moran Methodology

a. Area of Application. The Roberts and Moran methodology has been applied to the evaluation of text-editors only (Roberts & Moran 1983; Borenstein 1985).

b. Problems. The recording and classification of the problems experienced by users is original to this instrument. The analysis of errors and problems with using the system is included in the methodology because errors affect the user's performance, and may cause a drastic increase in interaction time (Arnold & Roe 1987). Secondly, errors may have negative emotional and motivational impacts on the user.(Arnold & Roe 1987). Errors may also be seen as evidence for inadequate human-machine interaction (Arnold & Roe 1987) and analysing the errors may provide information to improve the human-machine interaction (Arnold & Roe 1987; Janosky, Smith & Hildreth 1986; Norman 1983)

c. Purpose. This instrument is designed to yield useful information to improve the design of an interactive system. The Roberts and Moran methodology is primarily designed for the comparison of different text editors.

3.1.2 Hypotheses

The evaluation methodology is designed to test the following hypotheses. These hypotheses will be restated in more specific terms after the operational definitions of the variables (Paragraph 3.2.5.2).:

a. The interactive medical information system is easy to learn.

b. The interactive medical information system can be used to input and retrieve clinical data efficiently.

c. Such an interactive medical information system will be more efficient than a comparable manual medical record system.

3.1.3 Goal Attainment Model

In order to help in the design of the experiment, the goals (G_0 to G_2 on the diagram) which need to be attained in order to effectively use a medical record system were analyzed. The method and representation are derived from Abramson (1984). These goals can be attained through a series of actions (CA_0 to CA_2 for the computer system, and A_1 to A_2 for the manual system). This goal attainment model (Abramson 1984) provides a useful framework against which the influencing factors on the experiment can be viewed (Figure 3.1).

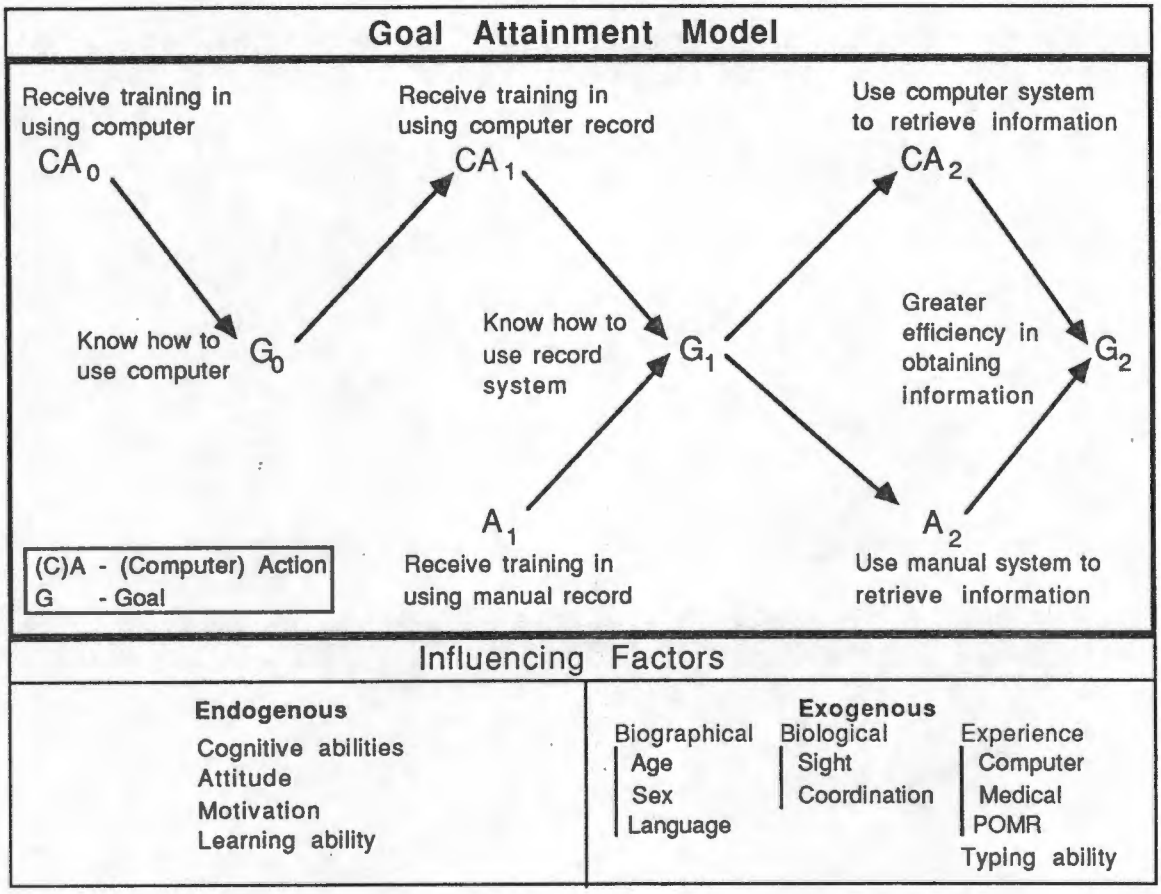

Figure 3.1: Goal Attainment Model

3.2 Method

3.2.1 Study population

3.2.1.1 Sampling

A volunteer sample of six doctors from the Primary Care (Family Medicine) Department of the HF Verwoerd Hospital and three doctors from Voortrekkerhoogte Hospital, both in Pretoria, was obtained.

3.2.1.2 Coverage/Representativeness

One subject from HF Verwoerd Hospital failed to complete the experiment, due to technical problems with the video recording of the final session. Each of the subjects was given a number for identification purposes. This number was used to identify all materials.

Although the number of subjects is limited, it is felt that the sample is large and varied enough for the purposes of exploring the usefulness of the proposed methodology, i.e. will the methodology deliver information that can be used to improve the design of

a interactive medical information system. The aim is not to make a definitive comparison between manual and computerized medical record systems. The variety in age and experience of the subjects is important in an explorative study of this nature in order to test the scope of the instrument. The limited availability of a TV studio for the experiment also placed a practical limit on the number of subjects which could be accommodated.

3.2.2 Materials

3.2.2.1 Manual Record System

The manual record system currently in use at the Family Medicine Department of HF Verwoerd Hospital was used. This is a problem-oriented medical record and a detailed description of the system is contained in Chapter Four. Medical records of twenty-five existing patients were selected. All of these records belonged to patients with reasonably complex case histories (more than ten current health problems). Complex records were selected on the assumption that limitations in interaction will be more readily apparent as the complexity of the information is increased. The patients all had regular follow-ups over a period of three to six years. High quality photostats were made of these records. The photocopied pages were stapled together in the original format of the record. All identifying information of the patients was removed and replaced with names selected at random from the Pretoria telephone directory. Where the subjects had to make notes in the record, removable pieces of paper were affixed in the appropriate places, and removed after completion. This ensured that each subject used an identical manual record. (cf. description of Session Four in paragraph 3.2.4.4). The number of records (25) was arbitrary and has no effect on the interaction with either the manual or the computer system, with the exception of selecting the patient's record on which the tasks were to be done. In all other cases information retrieval is optimized for retrieval within the patient record. Although this is the case in this particular computer record system it may not be so in *all* computerized systems. Retrieval of information within a patient record may be slower if there are more patient records on the system.

3.2.2.2 Computerized Medical Record System (IMIS)

A discussion of the design, development and function of this computer system can be found in Chapter Five.

The same patient records used for the manual record system were used for the computer system. These records were captured on the computer system and care was tak-

en to keep as close as possible to the content and form of the original records. This database was restored to its original form after use by each of the subjects.

3.2.2.3 Typing Tutor

A commercially available typing instruction program (Typing Tutor III, Kriya Systems) was used to measure and to improve the typing skills of the subjects. Typing skill was measured in terms of number of words typed per minute, as well as accuracy, expressed as a percentage, where 100% is equal to no typing errors.

3.2.2.4 Video Recordings

The final session with the subject was taped in a TV studio, utilizing three cameras. Camera 1 provided a close-up view of the computer screen; Camera 2 showed a frontal view of the subject down to table height. While the subject interacted with the computer, these two images were mixed together, using the "chroma" technique, in such a way that the image of camera 2 was shown super imposed on the image of the computer screen from camera 1. The image from camera 2 was kept in the lower right-hand corner of the image from camera 1 and obscured very little of the computer screen image (See Figure 3.2)

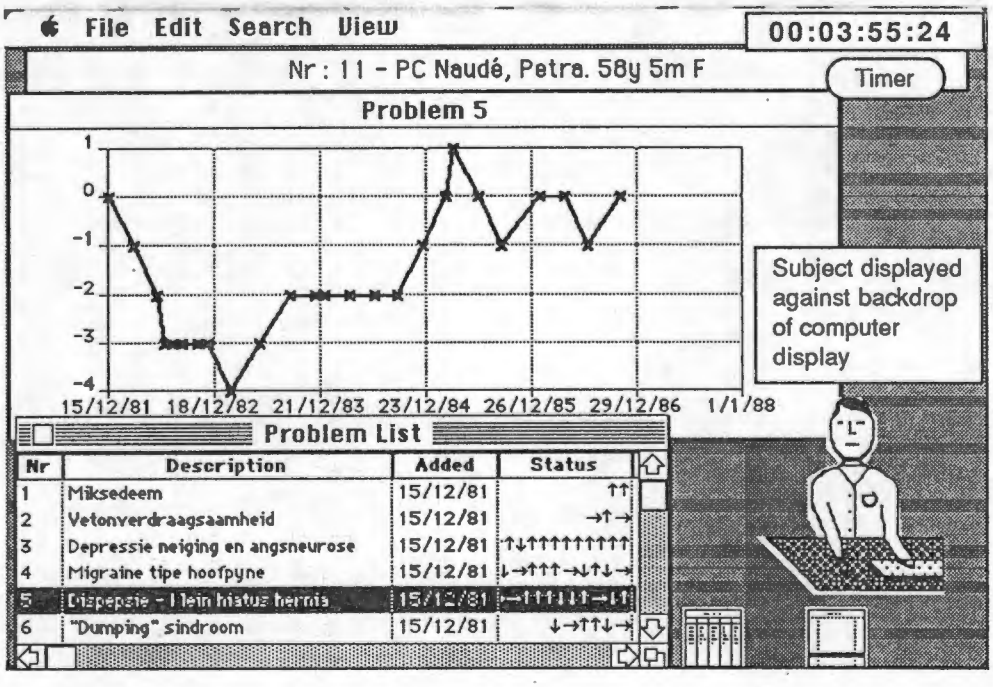

Figure 3.2: Video Image

From this video image it was easy to observe what the subject was doing on the computer screen while concurrently seeing his facial expression and hand movements.

The third camera was used to show a side view of the subject and the experimenter at the table. This image was recorded during the use of the manual record.

The experimenter and the subject each wore a neck microphone through which the conversation during the experiment was taped.

A timer, accurate to approximately one twenty-fifth of a second, was recorded on the video image. From this timer accurate measurements could be taken of the recorded events.

The subjects were not told beforehand that they would be video-taped. They were only told that the session would take place under experimental conditions. However, during the session itself it was evident to the subjects that they were being videotaped. The cameras were placed in a darkened section of the studio in order to keep the interference from the cameras to a minimum. Paragraph 3.2.4.4 describes the process of recording in more detail.

3.2.2.5 Questionnaire

The subjects were required to fill in a questionnaire at the start of the experiment. The questionnaire was completed in the presence of the experimenter who answered questions to clarify difficulties with the questionnaire. The subjects from HF Verwoerd Hospital and Voortrekkerhoogte Hospital completed the questionnaire in separate groups. One subject from Voortrekkerhoogte Hospital completed the questionnaire in his office with only the experimenter present.

The questionnaire consisted of three parts, a biographical section, a section concerning previous experience with computers and POMR, and a section on attitudes to computers. For an example of the questionnaire see Appendix D. The third part of the questionnaire was closely based on a questionnaire used by Teach and Shortliffe (1981), with minor changes: Question 12 was changed to read 'information' instead of 'knowledge'. This change was made because Teach and Shortliffe were interested in Decision Support Systems (DSS) whereas this research is about Information Systems. A final question was added about the appropriateness of this kind of system in third world countries. The Teach and Shortliffe questionnaire was used with little modification because it is commonly used and the results may be compared to the results obtained previously with the questionnaire.

3.2.2.6 User Manual

The user manual for the computer system consists of three parts (Appendix A). The first part gives the user an overview of the system and enables the user to build a consistent conceptual model of the system. The second part is based on a sample session with the system and carries the user through the actions necessary to add information to the system, to draw graphs and to select subsets of a patient's record. The third part contains a reference to common techniques in interacting with the system. The manual makes extensive use of graphical representation of sample screens from the system. (cf. Appendix A)

3.2.3 Variables

3.2.3.1 Tasks

The tasks used in the experiment are derived from the hierarchical taxonomy of tasks used in the design of the computer system (Chapter Five, par 5.5.1.3). A distinction is made between simple tasks and structured tasks:

a. Simple tasks involve only one component of the patient's record.

b Structured tasks involve more than one component of the patient's record.

A further distinction is made between data retrieval tasks and data capture tasks:

a. Data retrieval tasks do not add any new information to the patient's record.

b. Data capture tasks on the other hand add information to the patient's record, but may involve data retrieval tasks as a side effect; for instance, to add the status of a problem, the users must look up the problem number of the particular problem before they can complete the capture operation.

A complete list of the tasks follows:

3.2.3.1.1 Data Retrieval Tasks

R1. Open the patient's file.

R2. State the problem that was added on a particular date.

R3. State the date on which a particular problem was added.

R4. State when a particular problem was terminated.

R5. Determine the status of a problem at a given date.

R6. Determine the status of a problem the last time the problem was addressed.

R7. Read the text of the contact (Contact identified by date).

R8. Identify the contact that contains a given statement (Contact identified by date).

R9. Name all the medications given at a certain date.

R10. State when a certain medication was last given.

R11. State when the last referral for a specified reason was made.

R12. State if the result of a specified referral has already been received.

R13. Give the value of a named entry on the flow sheet at a certain date.

R14. State when a named entry on the flow sheet had a specified value.

R15. Describe what happened to problem x when the patient received treatment y.

R16. State whether a particular problem improved/worsened with time.

R17. Describe the change in dosage in treatment x and note when the change took place.

R18. Count the number of referrals of a particular kind.

3.2.3.1.2 Data Capture Tasks

C1. Open the patient's file

C2. Document that a contact has taken place.

C3. Capture the status of the current problems of the patient.

C4. Make the flow sheet entries.

C5. Write down notes for the patient.

C6. Add a problem to the problem list.

C7. Document a referral.

C8. Repeat current medications.

C9. Add new medications to the action list.

3.2.3.1.3 Task Components

A task can be broken down into a number of components (Figure 3.3):

a. Prompt. This is the question asked by the experimenter to prompt the subject to do the task.

b. Task Execution. This is the method the subject uses to arrive at the conclusion/answer as requested by the experimenter in the prompt to the task. There may be more than one correct method to execute a given task. A "correct" method is defined as a sequence of steps that will lead directly to the correct conclusion of the task. The correct conclusion to the tasks have all been determined beforehand by the experimenter through close scrutiny of the sample patient records.

c. Task Conclusion. In the case of data retrieval tasks this is the answer given by the subject to the question (Task prompt) put by the experimenter. In the case of data capture tasks, task conclusion is at the end of the final step in the capture task.

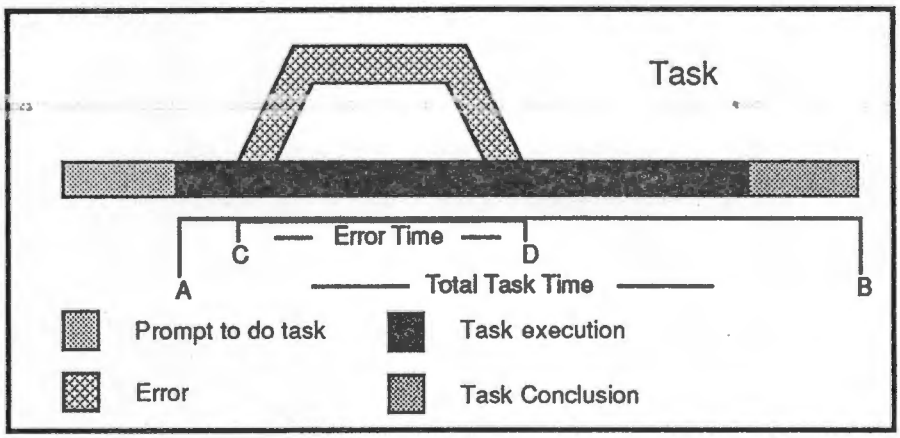

Figure 3.3: Task Components.

3.2.3.2 Error

An error is defined as a deviation from the correct method of executing the task. Typing mistakes which are not corrected by the subject are not taken as errors, because of their short duration. However if a typing mistake is corrected it is taken as an error (because of the longer duration), and the time needed to correct the typing mistake is added to the duration of the error.

3.2.3.3 Problem

A problem is defined as a hesitation/difficulty on the part of the subject in executing a task. A problem is described based on the context in which the hesitation occurred within the task. Errors are a subset of problems. A problem which is not an error therefore is a hesitation in executing the correct method for the task.

3.2.3.4 Time

A number of measurable intervals can be defined based on the above description of a task :

a Total Time. The interval from the end of the task prompt to the end of the task completion. This is taken as the time needed to execute the task.

b. Error Time. The interval from the start of an error until the end of the error, i.e. until the return to the correct method of executing a task. There may be more than one measurable error in a task.

c. Total Error Time. The sum of the error times per task.

d. Error Free Time. The difference between total time and total error time.

3.2.4 Methods Used for Collecting Information

The experiment was executed in four sessions:

3.2.4.1 Session One

For this session the subjects were seen in groups, one group being the six doctors from the Family Medicine Department of HF Verwoerd Hospital and the second group of two doctors from the Primary Care Department of Voortrekkerhoogte Hospital. The third doctor form this hospital was seen individually. At this session the questionnaire as described in Appendix D was administered to the subjects, followed by an explanation of the experiment. The subjects were told that the aim of the experiment was to compare the efficiency of a computerized medical record system with a manual record system. It was stressed that the aim of the experiment was to evaluate the computer system and not them. They were also told that the experiment would consist of a further three sessions and in broad terms about what would happen during those sessions. They were told that session four would take place under experimental conditions, but not that they would be videotaped during that session.

3.2.4.2 Session Two

The subjects were seen individually during this session. The aim of this session was to acquaint the subjects with the interaction techniques used on an Apple Macintosh Computer. The session took approximately one hour. Extensive use was made of computer assisted training packages on the Macintosh, namely MacCoach (©1984 American Training International) and Typing Tutor III (© Kriya Systems). The session proceeded as follows:

3.2.4.2.1 Introduction to the Computer

a. MacCoach - Introduction. This taught the subject how to use MacCoach.

b. MacCoach - Get Ready. This taught basic techniques such as the use of the mouse and pulldown menus.

c. MacCoach - Your Keyboard. The keyboard layout and function of special purpose keys.

d. Mouse Exercises. Training to improve the subject's skill with the mouse.

3.2.4.2.2 Typing Instruction

The subject was first tested using a standard speed test in the program Typing Tutor III. If the typing ability of the subject was less than 10 words per minute or his accuracy less than 90%, the subject received typing instruction. The subject carried on with this training until he/she was able to type at least 10 words per minute at an accuracy of greater than 90%. The subject was then retested using the standard speed test. The subject did two tests and the best score of the two was recorded.

3.2.4.2.3 Operating Concepts

This part of session two aimed at providing the subject with a more detailed knowledge of the operating concepts of the Macintosh.

a. MacCoach - Use Windows. The subject was introduced to the concept of windows, the movement, sizing and scrolling of windows.

b. Use Dialogues. The use of dialogues was explained to the subject, including the concepts of fields and movement between fields. The use of various controls such as buttons, check boxes and radio buttons were also demonstrated and explained.

c. Editing. Simple editing tasks such as typing in text, deleting, selecting, and copying were explained and the subject was given time to practise these skills.

3.2.4.3 Session Three

The subjects were seen individually for this session. The aim of this session was to acquaint the subjects with the computerized record system. The session took approximately one hour and fifteen minutes.

3.2.4.3.1 Introduction.

This part of the session was aimed at providing the subject with an overview of the system and to help them to form a correct conceptual model of the system.

a. An explicit conceptual model of the system was explained to them (Appendix A)

b. The experimenter demonstrated a sample session to them. This session was very similar to the capture tasks listed in paragraph 3.2.3.1.2. and showed how a consultation (contact) with a patient could be documented. The demonstration was done reasonably quickly and the subject was told not to concentrate on the details of what was happening, but rather to get an overall impression of the task.

3.2.4.3.2 Standard Techniques.

This part of session three had the purpose of acquainting the subject with the standard techniques used in interacting with IMIS.

a. Manipulating a Window. The subject was shown how windows are manipulated in the system. The meanings of the icons at the bottom of the screen was explained as well as how to use these icons to open windows. The concept of an "active" window was explained, especially the fact that commands only affect the "active" or front-most window. (See user manual, Appendix A)

b. Selection. The subject was shown how to select and to deselect a record within a window. Multiple selections were also explained. The purpose of selecting a record was explained and the fact that the action of menu commands often depends on the selection of one or more records.

c. Adding. The general method of adding a record to a window was demonstrated and explained.

d. Modification. The modification of existing records was also explained.

e. Searching. The technique of searching for a subset of records was demonstrated. The difference between a window displaying all records and those that displayed only a subset of records was pointed out.

f. Graphing. The subject was shown how to graph the contents of a flow sheet column or a problem and how to superimpose the duration of medications on a graph.

3.2.4.3.3 Sample Case

The subject was allowed to capture a sample case with assistance from the experimenter. Points of difficulty was explained and demonstrated as they arose. A sample case consisted of the following tasks:

a. Contact Identification. It is consultation x on date y.

b. Problem Status. The subject had to capture the status of a list of problems where problem "name" has improved, stayed the same, worsened or terminated.

c. Flow Sheet Entries. A list of flow sheet entries with the format: Entry "name", value "x" had to be captured by the subject.

d. Notes. The subject had to enter notes "xxxx" for the current consultation.

e. Problems. The subject had to add problem "name" to the patient's record.

f. Referrals. The subject had to document the fact that the patient had been referred for "name" to destination "x" with intention "y".

g. Actions. The subject had to document medications given to the patient where medications "x,y and z" were repeated for duration "t", and medication "s" added for duration "t" with dosage "d".

h. Additional Tasks

- Select subset of medications. The subject had to display all medications of type "y".
- Graph Flow Sheet entry. The subject had to display a graph of flow sheet entry "y".

- Graph Problem. The subject had to display a graph of the changes in status of problem "y".

3.2.4.3.4 Test Case

The subject was then required to do the same tasks as in the sample case (Paragraph 3.2.4.3.3), but this time without assistance. The subject was scored on his ability to do each of the tasks:

a. If the task was completed without errors four points were given.

b. If the subject made an error in the execution of the task which was corrected by the subject without assistance and the task was then completed successfully three points were given.

c. If the subject made an error in the execution of the task which was corrected with the assistance of the experimenter and the task was then completed successfully two points were given.

d. If the subject could not complete the task successfully one point was given.

Appendix D contains an example of the scoring sheet.

3.2.4.3.5 User Manual

The subject was given a user manual (Appendix A) and a form on which to record the time spent studying the manual. The subject was told that there was no minimum or maximum time that should be spent on the manual.

3.2.4.3.6 Manual System

No instructions were given on the manual system to the subjects from HF Verwoerd Hospital, because they used the system in their daily work. Although the manual system was familiar to the subjects from Voortrekkerhoogte Hospital they were not using this system on a daily basis. The subjects from Voortrekkerhoogte Hospital were given an instruction sheet on the manual system which they could study.

3.2.4.4 Session Four

Session Four is the evaluation part of the experiment where the manual system was compared to the computer system. The session consisted of seven parts that were arranged in such a way as to limit order effects and fatigue. Parts two to six were

videotaped (See paragraph 3.2.2.4). The total time of session four was approximately one and a quarter hours.

3.2.4.4.1 Typing Test

The typing test served two purposes. The first was to allow the subject some time to adapt to the unfamiliar environment and the second to document the typing abilities of the subject under the same circumstances as the evaluation that was to follow. The typing test was executed in the same fashion as during session two.

3.2.4.4.2 Manual Retrieval

The subject was asked to select the record of a specified patient from a pile of ±27 patient records in front of him. The experimenter then proceeded to ask the subject a series of questions about the patient. The answers to the questions were contained in the selected patient record. The questions were selected to be representative of the type of question the clinician would ask himself when confronted with the task of managing the specific patient. The structure of the questions is shown in paragraph 3.2.3.1.1.

3.2.4.4.3 Computer Capture

A sample consultation with a patient was simulated in this part in the same fashion as during the training in session three. The subject was given a series of prompts to add information to the patient record. The structure of the prompts is shown in paragraph 3.2.3.1.2. If the subject appeared to have insurmountable difficulties with using the computerized system, selective help was given by the experimenter. The help was restricted to the operation of the computer system.

3.2.4.4.4 Rest Period

The subject was allowed to rest for approximately three to four minutes.

3.2.4.4.5 Computer Retrieval

The subject was asked to select a specified patient from the list displayed on the computer. This patient was the same as the one used during manual retrieval, with the difference that the subject was now working on the computerized version of that patient's record. The subject was asked the same questions as in part two (paragraph 3.2.4.4.2). If the subject appeared to have insurmountable difficulties with using the computerized system, selective help was given by the experimenter.

3.2.4.4.6 Manual Capture

The subject was asked to select the record of a specified patient from a pile of ±27 patient records in front of him. The subject was given a series of prompts to add information to the patient record. The structure of the prompts were the same as in part three (paragraph 3.2.4.4.3) but a different patient was used.

3.2.4.4.7 Exit Interview

In conclusion the subject was interviewed by a psychologist. The interview was based on the following structure:

a. Attitude to experimental situation.

b. Attitude to manual medical record systems.

c. Attitude to computerized medical record systems.

d. Expectations about the future of medical record keeping.

3.2.5 Method of Processing Data and Statistical Techniques

3.2.5.1 Analysis of Video Recordings.

The recordings were made on Umatic format video cassettes and identified with the subject's identification number. For analysis purposes the cassettes were viewed on an SONY Umatic videocassette recorder with pause facilities and a colour TV monitor.

These recording were viewed by the experimenter and between two and four assistants. Two passes were made through the recordings:

a. Pass One. During this pass the time used for each task was measured using the following method: The moment the experimenter had completed the prompt for a task the play-back was stopped using the pause function on the VCR. The time shown on the digital display on the image was then recorded (T_s). The play-back was restarted and watched for signs of an error. At the start of an error the play-back was paused and the time noted (T_{es_1}). If necessary the tape was rewound to make sure that an error was not missed or that the start of an error was accurately determined. At the end of an error the play-back was paused again and the time noted (T_{ec_1}). This procedure was repeated for all errors that occurred during the execution of a task ($T_{es_{2..n}}$,$T_{ec_{2..n}}$) The play-back was paused again at the end of the task completion phase and the time on the recorded digital

display noted (T_c). Turns were taken by the experimenter and assistants for the operation of the VCR and the notation of the times, to prevent fatigue and associated errors. These times were processed with a simple Pascal program to yield the times defined in paragraph 3.2.3.1.3:

Total Time = T_c-T_s

Error Time$_n$ (E_n) = T_{ec_n}-T_{es_n}

Total Error Time = $\Sigma E_{1..n}$

b. Pass Two. During this pass the recording was studied to identify the problems experienced by the subjects in using the two record systems, as well as the accuracy with which the data retrieval tasks were executed. Data entry sheets were prepared beforehand for this task. (Appendix D). A data entry sheet for each task was produced, containing the task prompt and correct answer in case of a data retrieval task. When a problem was identified it was given a description and entered on the appropriate data entry sheet for the task. The subject that experienced the problem was also identified. If the same problem was experienced by a previous subject only a tick was made underneath the subject's number. The end result of this analysis was a sheet for each task showing the different problems experienced in the execution of a particular task as well as identifying the subject/s that experienced a given problem with that task. During this pass the times recorded in the first pass was checked for accuracy and redone if necessary. The problems were further processed by comparing problems between tasks and then standardizing the descriptions that referred to the same underlying problem. In some cases closely related problems were consolidated under one description.

3.2.5.2 Restatement of Hypotheses in more Specific Terms:

a. Hypothesis A. After a one hour training session in basic computer concepts and an one hour training session in the use of the interactive medical system subjects will be able to successfully complete 80% of a benchmark set of tasks.

b. Hypothesis B. After undergoing the training mentioned in Hypothesis A, subjects will spend less than 5%* of the time to execute a benchmark set of tasks in making or correcting errors.

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* The value of 5% is arbitrary, but it represents a small enough amount of time for errors not to be intrusive into the process of executing the tasks.

c. Hypothesis C. The computerized interactive medical record system will:

- result in shorter error-free times for tasks than the manual medical record.
- have fewer problems per task than the manual medical record.
- result in more correct answers for data retrieval tasks than the manual medical record.

3.2.5.3 Statistical Programs

Statistical analyses were done using SPSSX (© SPSS Inc) on an IBM compatible Mainframe and StatView 512+ (© BrainPower Inc) on a Macintosh SE.

CHAPTER FOUR : THE MANUAL MEDICAL RECORD

4.1 Introduction

The manual medical record system used in the study, is the record currently used by the Family Medicine Department of the Medical School of the University of Pretoria (Van den Berg 1981). The system is an adaptation of the Problem–oriented Medical Record (POMR) as described by Weed (Rakel 1977) and has been in use for the past ten years.

The system was chosen for the following reasons:

a. The system is well documented (Van den Berg 1977; Van den Berg 1985).

b. The system is used in the training of medical students and is suggested as an example for medical documentation by the South African Medical Association (Van den Berg 1985), therefore quite a number of doctors are familiar with the system.

c. The Family Medicine Department of the Medical School of the University of Pretoria has a history of being interested in patient documentation, therefore the study was undertaken as a combined project between the Family Medicine Department of the University of Pretoria and the Department of Bio-engineering of the University of Cape Town.

d. The system is an example of a well–established and efficient manual medical record system. Although the system follows the problem-oriented principle it has been specifically designed to be less cumbersome and time-consuming to use than the traditional Weed POMR.

The Family Medicine Department serves a number of general outpatient (primary care) clinics at various hospitals in the Pretoria area. Patients are seen at these clinics at regular intervals (monthly to quarterly) over relatively long periods of time (years). Patients are often seen by a different clinicians in the course of these follow-up visits.

4.2 Description

4.2.1 Introduction

The system is a POMR with the following components:

a. Identification and demographic details of the patient.

b. General clinical questionnaire.

c. Systematic clinical questionnaire.

d. Systematic examination.

e. Problem list.

f. Progress notes.

- Problem status.
- Notes.
- Flow Sheet.
- Referrals.
- Treatment.

b, c and d form the database of the traditional POMR.

4.2.2 Requirements

The system was designed to fulfil the following requirements (Van den Berg 1981):

a. A good basic clinical approach - effective enquiry and examination in the minimum time.

b. Purposeful long term follow-up.

c. Problem-oriented approach.

d. Time saving.

e. Uniformity.

f. Clarity.

g. Systematical.

h. A-4 format.

i. Good filing practices - the medical records of a family are kept in the same cover. Laboratory, radiological and other reports are kept separate from the patient file.

4.3 Detail Structure

4.3.1 Physical Layout

An example record is included in Appendix D. The paper record consists of four or more pages. Page one contains the identifying and demographic details of the patient, the general clinical questionnaire and part of the systematic clinical questionnaire. The questionnaires have the same layout, which consists of three areas across the page. The left hand area contains the numbered questions, the middle area contains two columns labeled "Yes" and "No", the right hand area contains space for numbered notes. (See figure 4.1).

	YES	NO	Nr.
1.		X	
2.	X		2. Head injury 1976.No after-effects. Fracture femur 1978
3.	X		3. Malaria 1975. Rheumatic Fever 1974, 1978,1981.
4.	X		4. Smokes 30 cig/day
5.	X		5. Weight gain, 15kg

Figure 4.1 : Questionnaire Layout

Date	Clinical data, new problems, follow-up notes	Weight	Pulse	Treatment
27.1.85	Major complaint: palpitations,increasing tiredness - 5 days. OE: BP 140/100.Pulse 110/min, irregular. No signs of failure. ECG 7 Atrial fibrillation Sedimentation rate: 10 mm/h Refer: Cardiologist - for cardioversion and possible surgery ☒ Conjunctivitis	85 kg	110	a) Penicillin, 500mg bd b) Anorectic (discont) c) Stop smoking d) Reduce weight e) Wondermycin, 5days
24.2.85	Improved : 2,6 ☒ Unchanged : 4 ☐ Influenza	83	66	Repeat : a Discontinue : c Cardioversion f) 'Cardiac suppressant' bd

Figure 4.2 : Progress Notes

Problem Description	Activity		Date		
	Act	Inact	Added	Discov	Solved
1 Recurrent rheumatic fever	X		27/1/85	1974	
2 Smoking	X		27/1/85	1982	
3 Allergy : Tricyclines		X	27/1/85		
4 Psoriasis	X		27/1/85		
5 Mitral valve lesion		X	27/1/85	1980	
6 Depression	X		27/1/85	1982	

Figure 4.3 : Problem List

Page two contains the rest of the systematic clinical questionnaire and space to record the systematic examination. Page Three contains space for progress notes (See Figure 4.2). The space is divided into two columns. The right hand column is used to record the treatment. The left hand column contains the date of the follow-up visit and the progress notes proper. This column may be optionally divided into more subcolumns, which are then used as flow sheets to record parameters that need to be monitored. The problem list is on page four, which can be folded out in such a way that the progress notes and problem list are visible at the same time. In addition to the problem description, the activity (active or inactive) of the problem is noted. The dates on which the problem was added, discovered and solved can also be recorded. (See Figure 4.3).

4.3.2 Identifying and Demographic Details of the Patient.

Refer to the example form included in Appendix D for detailed information on which data is gathered for this section.

4.3.3 General Clinical Questionnaire.

Positive as well as negative observations are indicated and further described by means of numbered notes to the right of the questionnaire. (c.f. Appendix D)

4.3.4 Systematic Clinical Questionnaire.

The systematic questionnaire is completed in the same way as the general clinical questionnaire (3.3.2). (c.f. Appendix D)

4.3.5 Systematic Examination.

The systematic examination is completed in the same way as the general clinical questionnaire (3.3.2). (c.f. Appendix D)

4.3.6 Problem List.

A numbered list of problems is kept, for the detailed layout see Appendix D.

4.3.7 Progress Notes.

Progress notes are added and recorded at each visit in the following format:

a. Problem status. Problems that have improved, stayed the same or worsened are noted by number.

b. Notes. Notes are written in the SOAP (subjective, objective, assessment and plan) format.

c. Flow Sheet. If needed columns are drawn on the record sheet to record values such as blood pressure, weight, blood glucose, etc.

d. Referrals. Referrals are outlined in the progress note text. Only positive findings are noted in the case of special investigations. Actual reports are filed elsewhere.

e. Treatment. The treatment is recorded in a separate column. A complete treatment list is kept at the top of the page. Each treatment is identified by a letter, which is used as a shorthand way to indicate whether a particular treatment has been repeated or discontinued at a specific follow-up visit.

4.4 Directions for Use

4.4.1 General Principles

The importance of the completion of a thorough history and clinical examination at the first visit is stressed. The starting point is the identification of the patient's problems, the listing of these problems, the establishment of how these problems are interrelated and the determination of relative urgency and importance. It is made clear to the users of the system that an orderly pattern of problem-orientated thinking is essential to ensure comprehensive, ongoing patient care.

4.4.2 First Visit

The main complaints are recorded in the first progress note. These complaints are identified as problems. The "General clinical questionnaire", "Systematic clinical questionnaire", and "Systematic examination" are completed. The appropriate squares in the "Yes" and "No" column are marked with an "X". Where no history was recorded or no examination was made, the spaces are left blank. If the answer is "Yes" an explanatory remark should be written next to the item. The unsolved problems identified when the history is recorded and the examination completed, are noted on the problem list and numbered. The notes should then be in the form of a summary of complaints and abnormal findings. New problems encountered during visits should not be added to the problem list immediately, but must be recorded in the respective progress note identified with a square containing the number of the problem. Only if these problems have not been solved by the time that the page must be turned over for the recording of additional progress notes should they be carried over to the list of unsolved problems. When follow-up management is required the deviating parameters, e.g. blood pressure, weight, should be indicated in the vertical columns to the left of the central vertical line — lines for these columns are drawn only when necessary. The medicines that are being taken at the first visit are listed vertically. Treatments are identified by a letter of the alphabet; other treatment such as "diet", "physiotherapy", should also be recorded. If special investigations are ordered these referrals are listed in the left hand column and enclosed in a rectangle. Adequate space should be left to record any positive results at a later stage. Referrals to consultants are noted in the same manner. Where applicable the notes are concluded with a "Plan", i.e. how the patient should be managed in future.

4.4.3 Return Visits

Summaries of reports and special investigations relating to previous visits are recorded in the space left for this purpose. The list of active problems is checked and the numbers of the problems which have improved are listed, as are the numbers of the problems that have stayed the same, or worsened. If a problem has been solved, the number of the problem is enclosed in a rectangle and crossed out. Medications which are repeated are listed by their alphabetic codes, e.g. "Repeat a,b,c".

CHAPTER FIVE : THE INTERACTIVE COMPUTERIZED MEDICAL RECORD

5.1 Introduction

This chapter documents the development of an interactive computerized medical record system (Interactive Medical Information System (IMIS)). IMIS was developed in order to provide an opportunity for testing the evaluation methodology described in this study.

In general, the design of the system incorporates the latest thinking in user interface design (specifically a direct manipulation interface), but is limited to providing adequate functionality in the retrieval and updating of problem-oriented medical records of ambulatory patients. The system does have real world validity because it provides all the information usually needed during the doctor-patient encounter. The major limitations of the system are in the area of patient administration and data-protection. This should have no effect as far as the evaluation methodology is concerned because it is foreseen that the clinician will mainly interact with the part of the system containing clinical information.

5.2 System Life Cycle

The development and operation of information systems evolve through consistent and logical phases (Ahituv & Neumann 1983 pp177-218). These phases or the system life cycle can be summarized as follows (Ahituv & Neumann 1983 p177):

a. The definition of the system.

b. The development of the system.

c. The implementation of the system.

d. The maintenance of the system.

These stages are only in a limited way applicable to the system under discussion here. The most important reason is that the system must be seen to be in the development phase and is still to be implemented. The second reason is that the system is not being developed to solve the information needs of a specific group of people, but as an experiment to investigate system design and development as it relates to interactive medical record systems. For these reasons the system will follow a modified life-cycle.

5.2.1 System Definition

a. Preliminary Analysis. The preliminary analysis usually contains the definition of the problem, the information requirements and the scope and boundaries of the information system. The content of the preliminary analysis done for IMIS will be essentially the same. The major difference is in the definition of the problem. Normally this definition is based on the information problems experienced by a real group of people. For IMIS it is twofold. On the one hand there are the problems experienced with current medical record systems by clinicians in outpatient departments in general, and on the other hand there are the problems experienced in the design and development of interactive medical records by the developers of such systems.

b. Feasibility Study. The purpose of a feasibility study is to establish whether a project should be done and how it should be done if justified (Ahituv & Neumann 1983 p193). Although the feasibility study is one of the most crucial stages in the information system life cycle (Ahituv & Neumann 1983 p221) it is relatively unimportant in the life cycle of IMIS. A feasibility study establishes the feasibility of a system in a particular environment where the system is intended to be implemented. IMIS is not intended to be implemented, therefore the feasibility study loses much of its relevance. Of the three major feasibility aspects — technological, economic, and organizational — only technical feasibility will be addressed in the case of IMIS.

c. Information Analysis. The primary purpose of the information analysis task is to transform its two major inputs — user requirements (conveyed in the preliminary analysis report) and a project charter (conveyed in the feasibility report) — into structured specifications (Ahituv & Neumann 1983 p194). This phase will be essentially the same for IMIS, because it only involves the logical transformation of the mentioned inputs into specifications; their content does not change the method of transformation.

5.2.2 System Development

The major differences in system development between IMIS and a traditional information system result mainly from the size of the system rather than from any fundamental considerations. The development of a complete computerized medical record system is a large project, which will require a number of people to work together during the development cycle. Current development methodologies are aimed at such projects. Because of the limited scope

of IMIS it can be designed and developed by a single person, making a large part of these considerations unnecessary.

5.2.3 System Implementation

IMIS will not be implemented in a real environment, but will only be used under experimental conditions. One aspect of implementation will remain though and that is user training.

5.2.4 System Operation

This phase will not take place in the life cycle of IMIS.

5.3 System Definition

5.3.1 Problem Definition

a. Problem. The program IMIS addresses two problems:

- From the perspective of the study — to obtain a program, during the development of which the evaluation methodology can be tested.
- From the perspective of information management in clinical medicine — to develop a system which can be used to retrieve and update clinical information used in the management of patients at an outpatient (ambulatory care) clinic.

b. Requirements

- From the perspective of the study:
  - The system should be sufficiently complex to serve as a reasonable design problem.
  - The problems posed by the design of the system should be comparable to the problems experienced in the design of real medical record systems.
  - The development of the system should be manageable by one person within a reasonable time period (6-8 months).
  - The program should incorporate a fundamental issue in the design of medical record systems. Of the several such issues available, user

interaction was chosen for the following reasons (See Chapter Two and Three for more detailed discussions):

a. Optimizing user interaction is a fundamental question in information system design in general (Gaines & Shaw 1986; Shneiderman 1987) and medical record system design specifically (Möhr 1977b; Barnett 1984).

b. Complete computerized medical record systems exist (Barnett 1984; Gottinger 1984; Pryor et al 1985), which address the broad range of issues associated with computerized medical records.

- The latest thinking in user interface design should be incorporated in the design of IMIS.

- The system may be developed to a limited scale, i.e. it need not accommodate a large number of patient records or multi-user operation.

• From the perspective of information management in clinical medicine:

- The system should be suitable for use in a primary care outpatient department.

- The system should be a computerized version of a medical record as it is used in a outpatient department and should implement the following components of the problem-oriented medical record:

a. Identifying and demographic details of the patient.

b. Baseline investigation

- General clinical questionnaire.
- Systematic clinical questionnaire.
- Systematic examination.

c. Problem list.

d. Progress notes.

e. Problem status.

f. Flow sheet.

g. Referrals.

h. Treatment.

- The system should be capable of interactive use by a clinician during consultation with the patient.

5.3.2 Feasibility Study

Because of the reasons elaborated in paragraph 5.2.1b only technological feasibility will be considered. The aspect that will be considered is which system (hardware and software) can best fulfil the criteria concerning user interaction.

Before any alternatives are considered the choice will be limited by the following considerations:

a. The system should be available to the researcher. It should be developed on a computer system that the researcher has access to, or a system which can be acquired with the available funds*.

b. The system will only need to accommodate a limited number of patient records. It will not be required to serve more than a single user at a time.

c. The system should be capable of interactive operation; this will exclude batch systems from consideration.

d. In order to support a direct manipulation interface the system should be able to display graphic images which can be manipulated interactively by a user on a visual display screen. This requirement excludes all multi-user systems to which the researcher has access.

The above considerations limit the choice to personal computers. Professional workstations are excluded on the basis of cost and/or access.

The following two alternatives will be discussed+ :

a. IBM-microcomputers and compatibles.

b. Apple Macintosh.

5.3.2.1 IBM-microcomputers and Compatibles

a. Advantages

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* The firm McAuto donated a sum of R15 000 to the Department of Family Medicine of the University of Pretoria for the purposes of this project.

\+ At the time of development the Commodore Amiga and Atari 1024 were not available in South Africa.

- A standard system that is commonly used both in universities and in private practice.
- A wide selection of development systems is available on these computers.
- Flexible configurations, to suit various requirements are possible with these machines.

b. Disadvantages

- A number of different graphics standards exist for these machines (Hercules, CGA, EGA, PGA, etc), which complicates matters for the development of graphic-based applications, because available development utilities are not optimized for a specific graphic environment.
- Bit-mapped graphics which include text as well as graphic images are difficult to accomplish on IBM-microcomputers and compatibles.
- Development systems that provide extensive support for the development of interactive graphic applications are not yet easily available for these machines.

5.3.2.2 Apple Macintosh

a. Advantages

- The system has a high resolution, bit-mapped graphic display.
- It has a well integrated mouse pointing device.
- It has a built-in iconic user interface.
- The operating system supports an overlapping windowing environment.
- The operating system provides efficient and consistent user interface routines (a "Toolkit" of routines – see paragraph 5.6.1.1)
- This user interface is the result of a concerted design effort to make the computer system more direct, effective and accessible (Apple 1986).

b. Disadvantages

- Limited support for Apple products is available in South Africa.

- Macintosh computers are not widely used in universities or private practices.

5.3.2.3 Choosing the Implementation Environment

The advantages of the Apple Macintosh™ outweigh its disadvantages, because of the study requirement that the latest thinking in user interface design should be incorporated in the development of the prototype system. The most important consideration against the IBM PC and compatibles is the lack of support for direct interaction applications. If IMIS were not a prototype system, the limited availability, lack of support and relatively high costs of the Macintosh would have been severe limitations.

5.4 Information Analysis

The information contained in IMIS will be closely based on the information structure of the manual medical record. Because of the importance of system interaction for this study, the requirements for user interface design will also be spelled out in this section. The section concludes with a conceptual design for the computerized medical record system.

5.4.1 Data Analysis of Manual Medical Record System

The structure of the manual record system has been discussed in Chapter Four. Normal data analysis techniques have been used in the analysis of the information structure of the manual record system (Howe 1983; Perkinson 1984). The methodology used in the data analysis is the one described by Howe (1983, pp.35-181). Data analysis is a methodology for gathering information and converting it into a logical data model (Perkinson 1984 p3). This data model can be used to design the database structure of an information system. Data elements are combined into groups which describe a particular entity. Such a grouping of elements is called a relation. There are a number of rules which define how data elements should be grouped together. The process of grouping the data elements together according to these rules is called normalization. A relation satisfying these rules is said to be in a normal form. There are a number of normal forms; each successive normal form satisfies more stringent normalization rules. The data structure described here satisfies third normal form. A relation is in the third normal form if all non-key attributes are directly and fully dependent on the keys of the relation. The advantages of the third normal form in practice are to minimize the redundancy of information and to minimize update anomalies (Delobel & Adiba 1985, pp411-413). The data analysis steps taken in the design of IMIS were as follows:-

a. Identification and definition of data elements.

b. The grouping of these data into small logical groups or entities, and the normalization of these groups.

c. Entity-relationship (E-R) Modelling. This model documents the relationship between the various entities.

The following relations were identified:

Relation 1. Patients. This relation contains the identification and demographic data on the patient.

Relation 2. Problem List Items. An entry into the problem list of the patient, i.e. one specific problem the patient experienced.

Relation 3. Contacts. The data describing one contact (consultation) between the patient and doctor.

Relation 4. Progress Notes. The free text notes the clinician made at a particular contact.

Relation 5. Problem Status. The data describing the status of a problem at a particular contact.

Relation 6. Action List Items. The data describing a particular treatment or action to the patient, which happened at a particular contact.

Relation 7. Referral List Items. This relation contains the the data elements which document a referral of the patient to a consultant or for special investigations. The actual result of the referral is not kept in this relation. Positive referral results are normally documented in the text of the progress notes.

Relation 8. Baseline. This relation contains the data describing a baseline examination.

Relation 9. Baseline Notes. This relation contains the free text notes that expand on findings documented in the baseline examination.

5.4.2 User Interface Requirements

As described in the literature survey (Paragraph 2.2.1.2) many guide-lines exist for the design of effective user interfaces. The guide-lines for the design of direct interaction dialogues as found in the Apple Human Interface Guidelines (Apple 1986) were followed, because

they are extensive and consistent with the overall design of the Macintosh computer. The following discussion of user interface requirements is based on this publication.

5.4.2.1 General Design Principles

a. Metaphors from the real world. The application should take advantage of the user's prior experience. This could be as general as the desktop metaphor used as systems interface by a variety of microcomputers, or it could be specific to the clinician's prior experience with the manual medical record system. With a paper flow sheet it is easy and simple for the doctor to add a new flow sheet column when the need arises; the computer system should provide the same natural extensibility.

b. Direct manipulation. Direct manipulation strengthens the perception of control over the computer (cf 2.2.3.1e). Users should be able to manipulate the windows in which information appear directly in order to place them in a convenient position.

c. See-and-point. The user selects from alternatives visible on the screen, instead of remembering commands. Users should be able to rely on recognition and not recall. The user interface should be visually and spatially ordered. The appearance and positions of the user interface components should be consistent. Users interact directly with the computer screen, pointing to and selecting objects they are interested in. The mouse is one of the most effective pointing devices currently available (Card, English & Burr 1978). An important paradigm in the Apple Desktop Interface is that users first select an object of interest and then select an action to be performed on the object. The basic assumption is that users can see, on the screen, what they are doing; and that they can point at what they see. All actions available for the object should be readily apparent. In a computerized medical record system, icons can represent the different components of the medical record. Users would then select the component of interest and then perform some action on the component, e.g. they would select the icon representing the problem list and then add a new problem to the list.

d. Consistency. Having learned a set of skills in one application, the user should be able to transfer that set of skills to a new application. On the highest level the user should be able to apply some of the skills acquired in the pen and paper world to the computer world e.g. the piece of paper one is currently writing on generally lies on top, or the currently active window is the one in front of all the other windows. On a lower level all applications on a given computer system (all

computer systems?), should act in a coherent way. This aim has been achieved to a significant degree on the Apple Macintosh systems. It also implies that IMIS should be consistent with the behaviour of other applications on the Macintosh. On a still lower level action within an application should be consistent, e.g. the button to confirm an action should always be on the same side of the dialogue rectangle (cf Figure 5.6).

e. User-initiated actions. The user and not the computer should initiate all actions. If the user attempts something risky the system should warn the user, but if the user persists the action must proceed.

f. Feedback and dialogue. The user should be informed of actions which are currently being undertaken by the system. Progress information should be clearly presented. An effective way to do this is to change the shape of the mouse pointer, e.g. to a watch shape to indicate that the system is busy, to a cross when selection operations are possible, or to an insertion beam when it is possible to type in text (cf paragraph 5.5.2.2).

g. Forgiveness. The user's actions should in general be reversible. It should be possible for the user to discover how the system works by exploration. In order to make this explorative mode of learning possible, actions should be reversible. If the user executes an action and is not happy with the result, he should be able to reverse the operation through a simple command. If it is technically impossible to provide this reversibility for a specific instance, then the user should be warned beforehand that this action is not reversible. The structure of the program should prevent errors, if the user makes too many errors in the process of learning the system, then something is wrong with the design of the system.

h. Perceived stability. The application should remain understandable to the user, things should not change randomly. Consistent screen design is very important in maintaining this perception of stability. On the typical Macintosh screen there are a number of consistent graphic elements — menu bar, window border, etc.

i. Aesthetic integrity. Consistent visual communication is very powerful in delivering complex messages and opportunities simply, subtly, and directly. Users should have some control over the look of their workspaces. This enables individual expression and relieves the system designer of having to devise one "look" that appeals to everyone.

j. Modelessness. With few exceptions, a given action on the user's part should always have the same result, irrespective of past activities. Modes are contexts in which a user action is interpreted differently than the same action would be

interpreted in another context. In some editors for example when the user types an "e" this character is stored in the document, however, when the user is in the command mode, this character will cause the program to terminate (exit) without saving the results of the current session. No mode should ever prevent the user from saving work or quitting the application.

k. Context and Concurrency. (Lynch & Meads 1986) Knowing, maintaining, supporting, and displaying context is a key element of the user interface. Context can be viewed in a broad sense or in a very narrow sense. In a broad sense the operating system needs to maintain a "national" context, i.e. a particular keyboard layout. In a narrow sense the application needs to maintain context for the user, i.e. the point the user is working at. Concurrency at one level could be adequate system response time, allowing for the implementation of direct manipulation, or it could be the simultaneous manipulation and viewing of several processes.

4.4.3. Conceptual Design of System

IMIS replaces the paper medical record of a patient. The doctor using IMIS will therefore enter his/her notes directly on computer while he/she is seeing the patient. If previous notes on the patient have been captured on computer, information can also be retrieved from the computer while the clinician is seeing the patient. IMIS implements the problem-oriented model of medical record keeping. All the familiar components of this model can be found in IMIS :

a. Baseline. This is a detailed record of the patient's condition at a particular time. This is normally done at the first visit, but can be repeated if necessary. The baseline investigation is also known as the "data base" in Weed's terminology.

b. Problem List. This is the most important single ingredient of the problem-oriented medical record (POMR). A problem is anything that requires diagnosis or management or interferes with quality of life as perceived by the patient.

c. Progress Notes. Progress notes are made at each contact (consultation) with the patient. No structure is imposed on these notes by the system, and the user is free to use any format that he is familiar with.

d. Action List. This list is primarily used to keep track of all medication given to a patient, but can also be used to record other actions, such as patient education, minor surgery, etc.

e. Flow Sheets. Flow Sheets are used to keep track of values such as blood pressure, weight, or laboratory tests such as fasting blood sugar.

f. Referral List. The referral list keeps a record of all referrals made for the patient. The actual referral report is not kept on the system. Positive findings are normally summarized in the progress notes.

g. Problem Status. The status of a problem is recorded at each contact (consultation). The status of a problem indicates whether a particular problem has improved, stayed the same, worsened, or has been resolved (terminated) since the last contact.

These components of the record can be acted on by the following command groups:

a. File. The commands in this group will allow the user to add instances (records) of the components listed above, to the patient's record. The file of a patient can also be opened and closed using commands in this group.

b. Edit. Existing records can be changed or deleted by using commands in this group.

c. Search. Records satisfying certain criteria can be searched for and displayed using commands in this group.

d. View. Special components of the patient's record can be viewed by this command, e.g. problem status and graphs.

The prototype system will be implemented on a single user microcomputer, and will cater to only a limited number of patients.

5.5 System Design

5.5.1 Design Methodology

5.5.1.1 Choosing a design method

The design of any information system depends on two important aspects, namely the structure of the data stored by the system, and the functions the system can perform on these data. The functions in turn depend on the user tasks which need to be supported by the system. Recently another aspect has come to the fore, (cf Chapter Two paragraph 2.3) the design of the user interface is becoming an important third element in the design of information systems.

5.5.1.2 Data Structure

5.5.1.2.1 Entity Relationship Model

An entity-relationship model describes the relationship between relations (as defined in paragraph 5.5.1.2.1) of the data-structure. There are only three linkage types: one to one (1..1), one to many (1..N), and many to many (N..N) (Perkinson 1984, p55). As an illustration of these linkage types, consider the following imaginary hospital information system: If we look at the International Classification of Diseases (ICD), a diagnosis contained in this classification can only have one code. There is a one to one relationship between the diagnosis description and its code. If diagnoses are codified according to this scheme a patient may be associated with more than one diagnosis and a particular diagnosis may be associated with more than one patient. There is a many to many relationship between patients and diagnoses. If the system keeps track of patients in a particular ward, there is a one to many relationship between a ward and the patients. A patient can not be in more than one ward at the same time.

Figure 5.1 gives a diagrammatic overview of the relations used in IMIS. The linkage type as well as the direction of the relation is indicated in Figure 5.1.

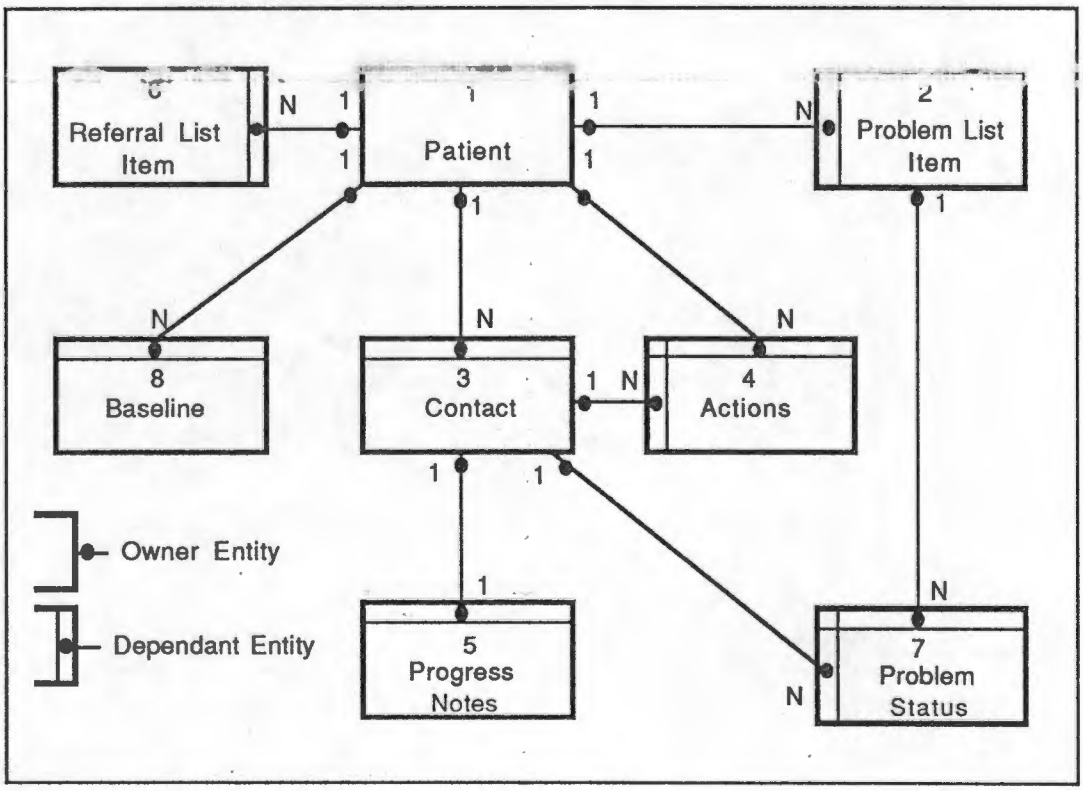


Figure 5.1: Entity Relationship Model

5.5.1.3 Task Analysis

Task analysis often forms the starting point of user interface design (Newman & Sproull 1979, p446). Task analysis is essential to establish the appropriate functionality of the system (Guedj 1981). Systems with inadequate functionality frustrate the user and are often rejected (Shneiderman 1987). Task analysis not only provides the criteria for the functionality of the system but is also important as a basis for structural decisions in the user interface design process. In this respect task frequencies are of particular importance (Shneiderman 1987). Task analysis is particularly important in systems making use of the direct manipulation style of interaction. In order to fulfil the first requirement of direct manipulation (cf paragraph 2.2.3.1e) that object and actions of interest be continuously represented, the designer needs detailed knowledge of the tasks the user will perform with the system. Only then can the "objects and actions of interest" be identified.

The task analysis used in the design of IMIS is based on a theory of clinical decision-making proposed by Elstein (Brooke, Rector, Sheldon 1984). This theory proposes an iterative process characterized by information gathering, hypothesis formation, and action taking. Hypothesis formation occurs early in the process and the subsequent actions may lead to further information gathering or may be therapeutic in nature.

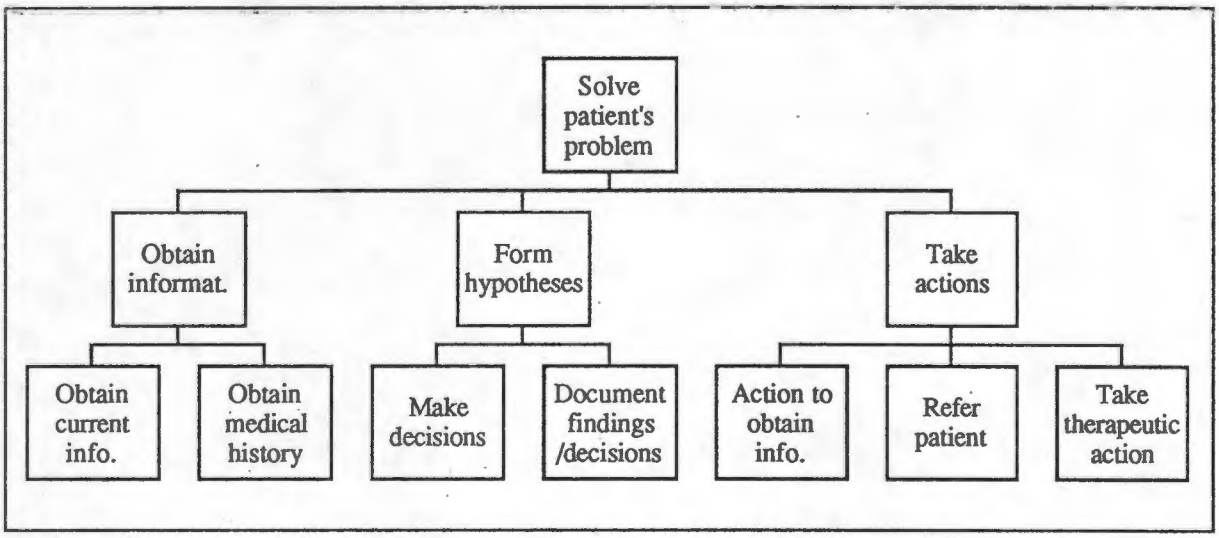


Figure 5.2: Task Structure

Figure 5.2 summarizes the results of the task analysis. The tasks are presented in a hierarchical way. The analysis deals with the tasks a clinician will normally perform in solving health-related problems of a patient in a ambulatory care setting. The tasks are subdivided into three main groups: those dealing with information gathering, hypothesis formation, and action taking. The tasks concerning the documentation of

actions or decisions have been grouped under hypothesis formation, because these tasks document the process of hypothesis formation.

5.5.2 Dialogue Management

The system closely follows the interface guide-lines as proposed by the Apple Company for application development on the Macintosh Computer (Apple 1986; Rose 1985). The Apple Desktop Interface is quite simple and consists of a few basic objects (the desktop, windows, menus) and a few basic actions (pointing, selecting, and keyboard input). A summary of the guide-lines is included here because the terminology introduced here is important to interpret the problem descriptions later on (Appendix B and C) :

5.5.2.1 Screen Elements

The screen should be an approachable representation of the available activities.

a. The Desktop. The desktop establishes the metaphor for the entire interface. It provides a stable surface upon which actions happen. The desktop stays the same between applications and within applications. Visually the the desktop appears as a gray background. The user controls the location and size of the the objects on the desktop. Icons (small pictures representing available objects) sit directly on the desktop. To select an object the user selects the corresponding icon, rather than having to type the name of the object it represents. In IMIS an icon represents a part of the medical record and when it is selected it can be opened to show the contents of that part of the record. Figure 5.3 shows the major components of the desktop. The icons used in IMIS are explained in figure 5.4.

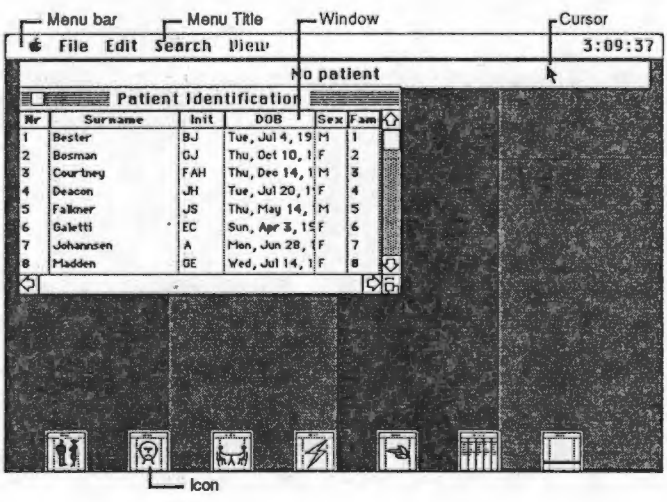


Figure 5.3 : IMIS Desktop (reduced)

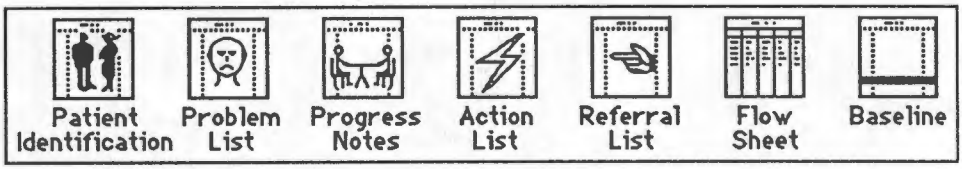


Figure 5.4: IMIS Desktop (icons)

b. Windows. A window (Figure 5.5) is a frame for viewing something. For example each IMIS window provides a view into a part of the patient record. To provide a *common* framework for the many kinds of information that the users interact with, windows are highly standardized. The number of windows opened at a time depends on the user (the maximum number depends on the application) and the size and position of these windows can be easily changed. These attributes of the windows make it easy for the user to arrange things so that the information of interest is visible at any given moment.

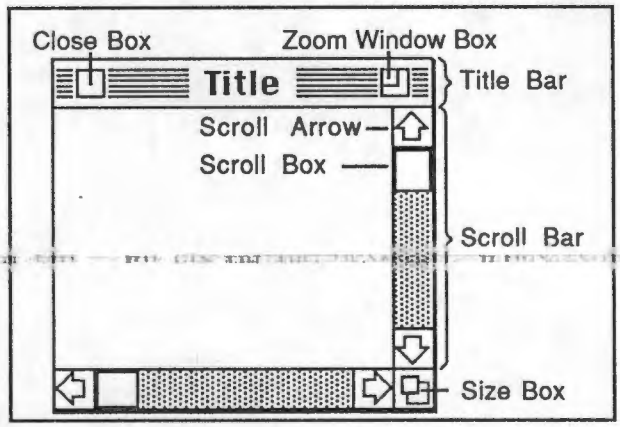


Figure 5.5 : The standard window.

There are standard conventions for opening, closing, moving, sizing, and scrolling windows. When the user manipulates windows on the screen, visual feedback is immediate. When users move windows, they have the sense of directly moving them. When users open or close windows they have the sense of such opening and closing. By using animation the illusion of a window closing "into" an icon, or opening "out of" an icon can be re-enforced. When a window is scrolled, the scroll box provides direct visual feedback about the position of the current view within the document as a whole.

All of these mechanisms emphasize user control and the direct manipulation of concrete objects.

c. Dialogues, Alerts, and Controls. A derivation of windows are dialogue and alert boxes and the controls associated with them. These boxes provide a framework in which the computer can present alternatives from which the user can choose. *Dialogues* are related to the form fill-in interaction style and present the user with a structured set of responses (Figure 5.6). When the dialogue box is complete the user dismisses it by "pushing a button" in the dialogue box (by clicking the mouse button while the screen pointer is within a button shaped object within the dialogue box). As a rule dialogue boxes have two buttons. An "OK" button which affirms the action represented in the dialogue box, and a "Cancel" button which returns the user to the state of affairs before the dialogue box was displayed.

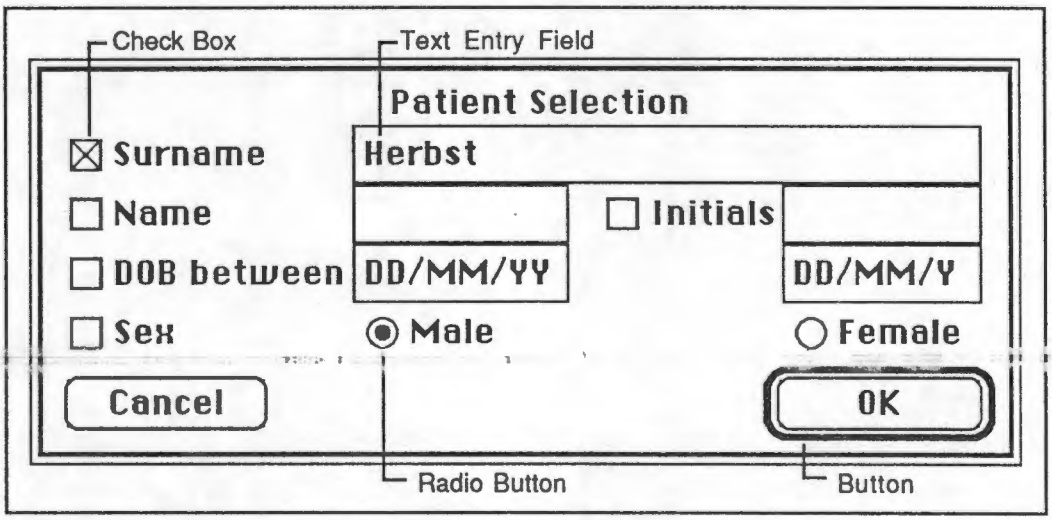


Figure 5.6: Dialogue with controls

Alerts (Figure 5.7) notify the user whenever an unusual situation occurs. They can warn of dangerous situations, recommend corrective actions, or provide information that might change the user's plans. There are different levels of alerts, according to the severity of the situation.

Standard *controls* are used within dialogue and alert boxes. Their appearance and functions are standardized. These controls include buttons, check boxes, radio buttons and text entry fields (Figure 5.6).

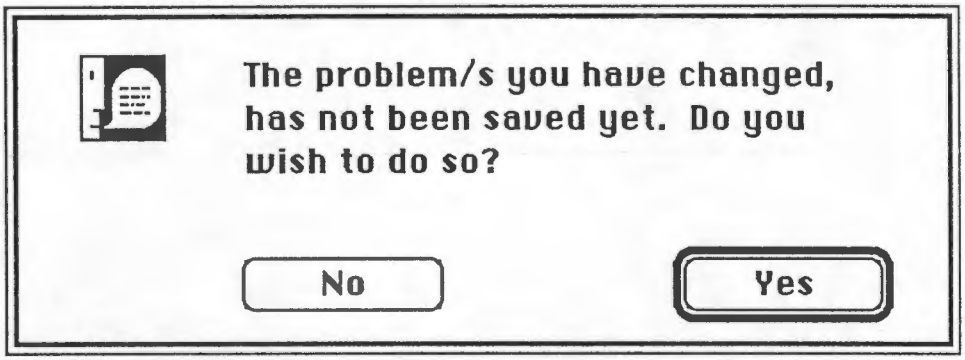


Figure 5.7: Alert.

c. Menus. Menus are central to the "noun-verb" principle of the Apple Desktop Interface". The user first selects an object (noun), either on the desktop or in a window, then chooses from a menu the action (verb) to be applied to this object. Menus display the full range of potential activities available and users simply have to choose the required alternative. The user's task is recognition, not recall. The concept of pull-down menus comprises three fundamental screen elements (Figure 5.3) : the menu bar, where the name of each available menu appears; pull-down menus, which appear only when the user wants them to; and the menu-items themselves. The menu is displayed when the user points to the menu title and presses the mouse button.

The *menu bar* is always visible at the top of the screen and serves as a stabilizing element. The menu titles are also quite stable. Three of the menus are standard — the Apple, File, and Edit menus.

The user can browse through the *menu items,* by simply holding down the mouse button and dragging the pointer across the menu titles. To choose an item from a pulled-down menu, the user drags the pointer down to that item and releases the mouse button. Menu titles or menu items which are not available at a given moment are dimmed.

5.5.2.2 Human-computer Interaction

The Apple Desktop Interface implements the direct manipulation style of interaction. The mouse lets the user point to objects, select objects with a click of the mouse button, move objects about, and choose actions to apply to the selected objects. Direct physical control over the work environment puts the user in command.

a. Pointing. The standard pointing device is the one-button mouse. A pointer on the screen follows the motion of the mouse (Figure 5.8).

Pointing allows the user to directly indicate which elements on the screen are relevant. Once an item is pointed to, it can be *selected* for action. Selection is normally done by clicking on an object. *Clicking* happens when the user presses down on the mouse button and quickly releases it while the mouse remains stationary. There is always a visual clue to show that something has been selected. This feedback should be immediate. Pointers on the screen assume different shapes, according to the context of the application, giving the users additional feedback about their interactions with the computer (Figure 5.8).

Pointer	Name	Used for
	Arrow	Scroll bar and other controls, menu bar, desktop, etc.
	I-beam	Selecting and inserting text
	Crosshair	Drawing and modifying graphic objects
	Plus sign	Selecting fields in an array
	Wristwatch	Shows that a lengthy operation is in progress

Figure 5.8 : Pointers

b. Keyboard Actions. The keyboard is not the central element in the Apple Desktop Interface, as it is in most other computer systems. The keyboard can provide alternative ways to accomplish some tasks, but it is not part of the direct manipulation interface. The keyboard is used for text entry and contains two kinds of keys: A *character key* sends, to the computer, a character that then appears on the screen. A *modifier key* alters the meaning of a character key if the modifier key is held down while the character key is pressed. A well-known example of a modifier key is the shift key. One modifier key, the command key, allows users to perform some operations — operations that are usually available only through menus — from the keyboard. The option modifier key allows the user to access an extended character set.

5.6 System Development

5.6.1 Development Environment

IMIS was developed on a Apple Lisa computer with 1MB of main memory and a 5MB hard disk. The development software that was used changed in the course of development. The greater part of the system was developed under the Lisa Workshop Development System running under the Lisa Operating System. This development system allows the development of Macintosh programs. The final version was developed in the Macintosh Programmer's Workshop (MPW) (Apple 1987) running under the Macintosh Operating System. The programming language is Pascal, with a few optimized routines written in Assembly language. The change was made made due to the natural evolution of the Apple development products and the change entailed no notable code changes in the IMIS program.

5.6.1.1 Macintosh System Support

Programs developed for the Macintosh may use the Macintosh User Interface Toolbox. The Toolbox provides a simple means of constructing application programs that conform to the standard Macintosh user interface (cf paragraph 5.5.2), by offering a common set of routines that every application calls upon to implement the user interface. The following is a short summary of the facilities provided by the Toolbox (Rose 1985):

a. Resource Manager. The object code files of Macintosh applications are more complicated than those of other microcomputers. In addition to the object code, other resources are also stored in the object code file. These resources include menu specifications, strings for error messages, dialogue and window specifications etc. These resources can be changed by a resource editor. This allows the developer to change the outward appearance of the application without recompilation. The retrieval of these resources for use by the program is handled by the resource manager.

b. QuickDraw. All graphic operations on the Macintosh are performed by QuickDraw. QuickDraw implements a set of graphic primitives to draw lines, rectangles, text, bitmaps, etc.

c. Font Manager. The Font manager does the background work necessary to use a variety of text fonts on the Macintosh. An application seldom calls the Font Manager directly.

d. Event Manager. The application decides what to do from moment to moment by responding to user input in the form of mouse and keyboard actions. It learns of such actions by repeatedly calling the Event Manager. The Event Manager also reports occurrences which may require a response from the application program, such as when a window that was overlapped becomes exposed and needs to be redrawn.

e. Window Manager. To create windows, activate them, move them, resize them, or close them, the Window Manager is called. It keeps track of overlapping windows and provides information to the program in which part of a window the user has pressed the mouse.

f. Control Manager. Controls such as buttons, check boxes and scroll bars, are created and manipulated by calling the Control Manager.

g. Menu Manager. The Menu Manager is used to display and manipulate menus. It takes care of displaying a menu and reports back to the application which item from which menu has been selected by the user.

h. TextEdit. TextEdit implements a simple word processor. It allows the cutting and pasting of text and word wrap. An application program may integrate these facilities by making calls to TextEdit.

i. Dialogue Manager. To create dialogues and find out the user's responses to them the application program calls the Dialogue Manager.

k. Desk Manager. This manager allows a program to support any desk accessory that has been installed in the Apple menu.

l. Toolbox Utilities. Some generally useful operations such as fixed point arithmetic, string manipulation and logical operations may be performed with the Toolbox Utilities.

m. Package Manager. The Package Manager lets the programmer use RAM-based software called packages. The Standard File Package can be called by any application to identify files for opening or creation. The Binary-Decimal Conversion Package converts integers to strings and vice versa. The International Utilities Package gives the programmer access to country-dependent information such as the formats for numbers, currency, dates and times.

n. Operating System and other Low Level Software. Facilities are provided by the system software to access hardware features directly if needed.

5.7 System Description

5.7.1 Conceptual Description

5.7.1.1 Conceptual Model

IMIS replaces the paper medical record of a patient. The doctor using IMIS will therefore enter his/her notes directly on computer while he/she is seeing the patient. If previous notes on the patient have been captured on computer, information can also be retrieved from the computer while the user is seeing the patient.

IMIS implements the problem-oriented model of medical recordkeeping. More detailed information can be found in the User Manual in Appendix A.

5.7.1.2 Program Structure

The program consists of twelve segments :

a. Main. This segment contains the main event loop of the program. The main event loop waits on events generated by the user or the program internally and calls the appropriate routines to deal with these events. Frequently used code are also kept in the main segment, notably the code to update the various window displays.

b. INIT. This segment contains the initialization code which opens the datafiles and sets up the desktop with the various icons and windows.

c. OPCLSEG. When a patient file is opened or closed, the necessary housekeeping tasks are performed by the code contained in this segment.

d. SHOWSEG. Code in this segment is responsible for displaying the dialogues for adding records to the various parts of the patient record.

e. BASESEG. The baseline information and window are displayed by this segment.

f. NOTESEG. This segment contains the code to capture the free text notes used in the baseline and progress notes components of the patient record.

g. STATSEG. The problem status window is displayed and the problem status information is captured by the routines contained in this segment.

h. SELSEG. The selection of a limited set of records from a patient file is handled by this segment.

i. GRAPHSEG. The code for drawing and displaying graphs is contained in this segment.

j. PDBSSEG. This segment contains the code for data storage and retrieval (data base management).

k. CHAINSEG. This segment implements a different type of file management needed for the flow sheets. It allows for the easy addition of fields to existing records.

l. LISTSEG. This segment also contains code needed for flow sheets, namely the display of lists of data and the editing of data in these fields.

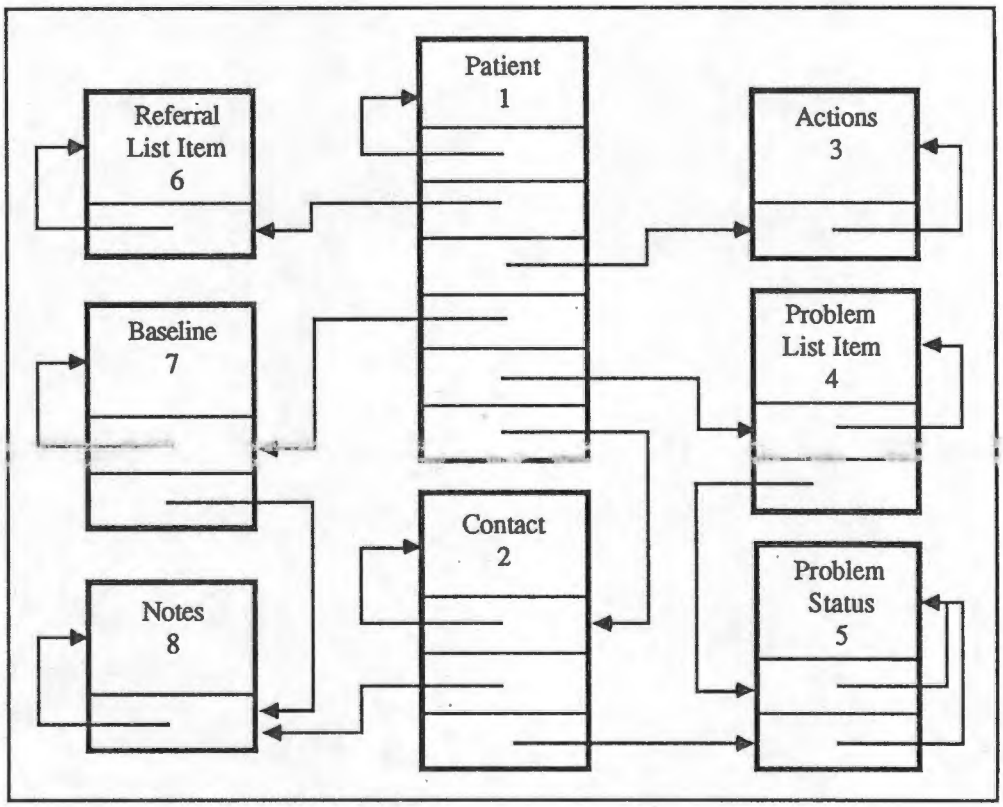


Figure 5.9 : Database Schema

5.7.1.3 Data Structures

The patient data is kept in nine files, of which the first eight represent normalized relational tables. The ninth file contains the variable length records for the flow sheet data. To facilitate retrieval these files contain pointers to each other and links between the records (doubly linked circular chains). Figure 5.9 gives an overview of the data file organization.

5.7.2 User Manual

Appendix A contains the user manual. The manual is the same as the manual used by the subjects during user training.

5.7.3 System Limitations

Maximum number of patient records : 32767

Average size of a patient record : 14,2Kb
(28 patients with medical records spanning 3-4 years)

Minimum possible size of a patient record : ±700 bytes
(One problem, one contact, one action, one referral)

Maximum possible size of a patient record : (n=number of patients on system)
- Average number of Problems/patient : 32767 divided by n
- Average number of Contacts/patient : 32767 divided by n
- Average number of Actions/patient : 32767 divided by n
- Average number of Referrals/patient : 32767 divided by n.

CHAPTER SIX: RESULTS OF THE EVALUATION

6.1 Introduction

This chapter describes the results obtained from applying the evaluation methodology described in Chapter Three to the manual and computerized medical record systems described in Chapters Four and Five.

6.2 Results

6.2.1 Questionnaire

6.2.1.1 Demographics

No	Item	Subject							
		1	2	3	4	5	6	7	8
1	Age	26	32	37	25	34	68	26	27
2	Sex	M	M	M	F	M	M	M	M
3	Language of choice[1]	A	A	A	A	A	E	A	A
4	Years since internship	3	8	9	1	10	44	2	1

Notes to Table 6.1:
[1] A= Afrikaans, E=English

Table 6.1 : Demographics

6.2.1.2 Relevant Experience

No	Item	Subject							
		1	2	3	4	5	6	7	8
1	How often do you use a computer?[1]	1	1	3	3	5	1	4	5
2	My knowledge about computers is[2]	2	2	2	2	4	2	2	2
3	Used a computerized medical record system before	N	N	N	N	N	Y	Y	Y
4	How often?[3]	-	-	-	-	-	5	4	5
5	Own a personal computer	N	N	N	N	Y	N	N	N
6	Priority of medical administrative applications[4]	4	4	4	4	4	4	4	5
7	Priority of clinical applications[4]	4	4	4	4	3	5	4	5
8	Prepared to enter own notes in computer.	Y	Y	Y	Y	Y	Y	Y	Y
9	Familiarity with POMR[5]	3	4	4	3	4	3	3	3

Notes to Table 6.2:
[1] Never=1,Yearly=2,Monthly=3,Weekly=4,Daily=5
[2] None=1,Below average=2,Reasonable=3,Above average=4,Excellent=5
[3] Almost never=1,Yearly=2,Monthly=3,Weekly=4,Daily=5
[4] Very low=1,Low=2,Moderate=3,High=4,Very high=5
[5] None=1,Little=2,Reasonably=3,Above average=4,Very familiar=5

Table 6.2 : Experience

6.2.1.3 Attitude

Table 6.3 shows the attitude of the subjects to various statements about computerized medical record systems. The attitude scores are converted from the original Likert scale statements in the questionnaire (Teach & Shortliffe 1981; Jagodzinski & Clarke 1986) (Strongly disagree, Disagree, Undecided, Agree, Strongly agree) to the values 2, 1, 0 -1, -2. All of the statements have been formulated in such a way that disagreement signifies a positive attitude to computerized medical record systems. For example, disagreement with the statement "Computerized medical record systems will dehumanize medical practice" is taken as a positive attitude to these systems. If the subject strongly disagreed with the statement it was taken as a strongly positive attitude.

No	Item[1]	Subject								
	Computerized medical record systems will (be)...	1	2	3	4	5	6	7	8	Avg
1	increase government control over dr's practices	-1	0	1	0	-1	0	-1	-1	-0,38
2	blamed by pats for errors in management	0	1	1	1	2	0	1	1	0,88
3	increase cost of health care	1	2	1	0	0	0	-1	0	0,38
4	threaten personal & professional privacy	1	-1	1	1	2	1	-1	1	0,63
5	result in serious legal & ethical problems	0	-2	1	1	1	1	1	0	0,38
6	threaten the doctor's self image	1	1	1	1	2	2	1	2	1,38
7	difficult for physicians to learn	0	-1	0	1	1	1	-1	1	0,25
8	diminish clinical judgement	1	-1	1	1	1	1	-1	1	0,50
9	diminish patient's image of a doctor	1	1	1	1	1	1	0	2	1,00
10	unreliable because of computer malfunctions	0	0	1	1	2	0	1	2	0,88
11	dehumanize medical practice	1	1	1	1	1	2	-1	2	1,00
12	contain information which is not up-to-date	1	0	1	1	1	1	2	1	1,00
13	alienate physicians because of gadgetry	0	1	1	1	1	2	-1	1	0,75
14	force doctors to think like computers	1	-1	1	1	-1	2	0	2	0,63
15	reduce need for paraprofessionals, ie nurses	1	-1	1	1	2	0	1	1	0,75
16	reduce need for medical specialists	1	1	1	1	-1	1	2	1	0,88
17	result in less efficient use of a physician's time	1	2	1	1	2	1	1	1	1,25
18	inappropriate for developing countries	1	0	1	0	1	0	-1	2	0,50
	AVERAGE	0,6	0,2	0,9	0,8	0,9	0,9	0,1	1,1	0,70

Notes to Table 6.3:
[1] -2 = Strongly negative, -1 = Negative, 0 = Neutral, 1 = Positive, 2 = Strongly positive

Table 6.3 : Attitude

The relatively low number of zeros indicates that there was no central tendency in answering the questionnaire.

6.2.2 Typing Ability

No	Item	Subject							
		1	2	3	4	5	6	7	8
1a	Typing speed before training[1]	9	5	11	-	-	4	7	8
1b	Accuracy before training (%)	98	-	99	-	-	96	98	98
1c	Corrected[2]	9,8	-	12,1	-	-	4,3	7,6	8,7
2a	Typing speed after training[1]	12	9	13	10	32	7	10	11
2b	Accuracy after training (%)	98	97	99	98	95	97	99	99
2c	Corrected[2]	13,0	9,7	14,3	10,9	33,8	7,5	11,0	12,1
3a	Typing speed before evaluation[1]	13	9	13	9	27	7	10	12
3b	Accuracy before evaluation (%)	99	94	99	98	95	97	98	99
3c	Corrected[2]	14,3	9,4	14,3	9,8	28,5	7,5	10,9	13,2

Notes to Table 6.4:
[1] Words per minute. [2] Speed x (Accuracy/90)

Table 6.4 : Typing Ability

6.2.3 Learning

No	Item[1]	Subject								
		1	2	3	4	5	6	7	8	%
1	Select patient	4	4	4	4	4	2	4	4	93,8
2	Open patient file	4	4	4	4	4	4	3	4	96,9
3	Create contact	2	2	2	4	2	2	2	2	56,3
4	Document problem status	2	3	4	3	3	2	3	2	68,8
5	Add flow chart items	3	4	4	2	4	2	4	3	81,3
6	Modify progress notes	4	2	2	3	4	2	2	2	65,6
7	Add problem	4	4	4	4	4	2	4	4	93,8
8	Update referral	4	3	3	2	2	2	2	3	65,6
9	Add referral	4	3	2	4	4	2	4	4	84,4
10	Repeat actions (medications)	2	2	2	3	3	2	2	2	56,3
11	Add action (medications)	4	3	4	4	4	3	3	3	87,5
12	Select subset of actions	2	2	4	2	2	2	2	2	56,3
13	Graph flow chart item	3	4	2	4	3	2	3	4	78,1
14	Graph problem	4	4	4	4	4	2	4	2	87,5
15	Close patient file	4	4	4	4	4	4	4	4	100
	PERCENTAGE out of 60 (%)	83,3	80,0	81,7	85,0	85,0	58,3	76,7	75,0	78,1

Notes to Table 6.5:
[1] 1 = Not Completed; 2 = Helped; 3 = Self corrected error; 4 = No errors

Table 6.5 : Learning Tasks

6.2.4 Use of Manual and Time between Sessions

No	Item	Subject							
		1	2	3	4	5	6	7	8
1	Time spent with manual (mins)	130	55	180	20	35	195	60	130
2	Time between session 2 & 3 (days)	10	9	7	15	14	3	1	1
3	Time between session 3 & 4 (days)	7	8	10	12	9	5	2	7

Table 6.6 : Manual Use & Time between sessions

6.2.5 Task Performance

No	Item		Subject								
			1	2	3	4	5	6	7	8	Avg[2]
1a	Manual Retrieval	Total Time[1]	8,0	7,7	16,9	10,2	17,5	17,2	9,8	10,6	12,2
1b		Error Time[2]	0	0	2,1	0,3	6,4	0	0	12,8	2,9
2a	Computer Retrieval	Total Time	14,9	14,3	17,8	12,6	24,6	26,1	15,2	17,3	17,8
2b		Error Time	18,5	23,3	21,1	7,1	24,0	8,3	21,7	21,2	18,0
3a	Manual Capture	Total Time	2,7	3,2	5,3	3,1	3,8	4,3	3,8	3,1	3,7
3b		Error Time	0	3,7	0	0	4,5	0	0	0	1,1
4a	Computer Capture	Total Time	10,0	13,5	14,0	15,1	12,7	19,0	13,4	13,7	13,9
4b		Error Time	14,6	8,1	14,0	11,2	16,3	13,7	12,6	14,8	13,1
5	Manual / Computer	Retrieval[3]	1,5	1,4	0,9	1,2	1,1	1,4	1,2	1,5	1,3
6	Manual / Computer	Capture[3]	3,2	4,0	2,3	4,3	2,9	3,8	3,1	3,8	3,4

Notes to Table 6.7:
[1] Times in minutes and decimal parts of minutes,
[2] Error time is given as a percentage of the total time.
[3] Computer error free time divided by manual error free time

Table 6.7 : Tasks Times

6.2.6 Problems

The classification of the tasks is the same as in paragraph 3.2.3.1.1 and 3.2.3.1.2. The observed problems are classified into five groups, see the discussion of these groups in paragraph 6.3.7.

No	Item		Subject								
			1	2	3	4	5	6	7	8	Total
1	Manual Retrieval	Problems	7	6	15	9	12	10	7	9	75
2	Computer Retrieval	Problems	15	21	20	13	36	31	21	18	175
3	Manual Capture	Problems	0	1	1	4	0	5	0	0	11
4	Computer Capture	Problems	11	12	21	19	16	18	14	13	124
5	Lexical	Problems	3	4	7	7	6	13	5	3	48
6	Syntactic	Problems	10	7	9	6	18	13	10	12	85
7	Semantic	Problems	9	14	16	6	11	10	10	6	82
8	Conceptual	Problems	5	5	7	10	6	10	8	8	59
9	Find	Problems	6	10	18	16	23	18	9	11	111
10	Total Number of	Problems	33	40	57	45	64	64	42	40	385

Table 6.8 : Problems

6.2.7 Type of Problem by Task Group

No	Error Type	Task Group				
		Manual Retrieval	Computer Retrieval	Manual Capture	Computer Capture	Total
1	Lexical Problems	0	33	0	16	49
	Avg problems/task/subject	0,00	0,23	0,00	0,22	0,11
2	Syntactic Problems	0	27	0	58	85
	Avg problems/task/subject	0,00	0,19	0,00	0,81	0,20
3	Semantic Problems	25	45	0	12	82
	Avg problems/task/subject	0,17	0,31	0,00	0,17	0,19
4	Conceptual Problems	0	30	0	30	60
	Avg problems/task/subject	0,00	0,21	0,00	0,42	0,14
5	Problem with Finding	50	41	11	9	111
	Avg problems/task/subject	0,35	0,28	0,15	0,13	0,26
6	TOTAL	75	176	11	125	387
	Avg problems/task/subject	0,52	1,22	0,15	1,74	0,90

Table 6.9 : Type of Problem by Task Group

6.2.8 The most common Problems per Task Group

No	Error Description	Task Group		
		Manual Capture	Manual Retrieval	Total
57	Difficulty with readability of record	6	9	15
31	Difficulty in interpretation of conventions	0	14	14
58	Difficulty with record format	0	11	11
66	Incomplete record	0	10	10
71	Unclear information on record	0	7	7
	TOTAL	6	51	57
	Percentage of all Problems in Group	54,5%	68,0%	66,2%

Table 6.10 : Common Problems with Manual Tasks

No	Error Description	Task Group		
		Computer Capture	Computer Retrieval	Total
47	Unsure about method	22	28	50
6	Difficulty with scrolling	6	14	20
20	Difficulty with termination	16	0	16
40	Inappropriate use of search command	0	13	13
50	Difficulty in finding item in table	1	10	12
35	Difficulty with interpretation of graph	0	10	10
13	Difficulty in selecting correct icon	5	5	10
37	Difficulty with subset of records	0	9	9
18	Difficulty with dialogue fields	8	1	9
2	Clicked twice on selected record by mistake	2	7	9
46	Unnecessary scroll of window to add entry	8	0	8
22	Gave menu command for inactive window	0	8	8
	TOTAL	68	105	173
	Percentage of all Problems in Group	54,4%	59,7%	57,5%

Table 6.11 : Common Problems with Computer Tasks

6.2.9 The Tasks with the most Problems in a Task Group

No[1]	Task Description	Problems	
	MANUAL RETRIEVAL	Freq	%[2]
4	When was problem terminated	11	14,6
18	How many referrals of a certain kind were there	10	13,3
9	Which medications were given on date	8	10,6
11	When was a specific referral last done	8	10,6
15	What happened to problem while receiving meds	8	10,6
17	When & how was dosage changed	8	10,6
	TOTAL[3]		70,6

Notes to Table 6.12:

[1] Task number in task group,

[2] Percentage of total number of problems in task group.

[3] The percentage of all problems in task group represented by the listed problems

Table 6.12 : Manual Retrieval Tasks with the most Problems

No[1]	Task Description	Problems	
	COMPUTER RETRIEVAL	Freq	%[2]
5	What was problem status on date	37	21,1
15	What happened to problem while receiving meds	37	21,1
9	Which medications given on date	19	10,9
8	Find statement in progress notes	14	8,0
10	When was a specific medication last given	9	5,1
11	When was a specific referral last done	9	5,1
	TOTAL[3]		71,4

Notes to Table 6.13:

[1] Task number in task group,

[2] Percentage of total number of problems in task group.

[3] The percentage of all problems in task group represented by the listed problems

Table 6.13 : Computer Retrieval Tasks with the most Problems

No[1]	Task Description	Problems	
	MANUAL CAPTURE	Freq	%[2]
8	Repeat actions	6	54,5
	TOTAL[3]		54,5

Notes to Table 6.14:

[1] Task number in task group,

[2] Percentage of total number of problems in task group.

[3] The percentage of all problems in task group represented by the listed problems

Table 6.14 : Manual Capture Tasks with the most Problems

No[1]	Task Description	Problems	
	COMPUTER CAPTURE	Freq	%[2]
3	Document problem status	24	19,4
4	Add flow sheet entries	22	17,7
8	Repeat actions	20	16,1
5	Do progress notes	15	12,1
2	Add contact	14	11,3
9	Add actions	14	11,3
	TOTAL[3]		88,9

Notes to Table 6.15:

[1] Task number in task group.

[2] Percentage of total number of problems in task group.

[3] The percentage of all problems in task group represented by the listed problems

Table 6.15 : Computer Capture Tasks with the most Problems

6.2.10 Comparison of Task Times between Computer and Manual System

No[1]	Task Description[2]	Time (min)[3]		
	RETRIEVAL	Comp	Manual	Difference
5	What was problem status on date	2,14	0,41	1,73
15	What happened to problem while receiving medications	2,45	1,13	1,33
8	Find statement in progress notes	1,62	0,90	0,72
4	When was problem terminated	0,67	1,13	-0,46
18	How many referrals of a certain kind were there	0,51	1,01	-0,50
16	What was the change in problem status over time	0,41	0,94	-0,53

Notes to Table 6.16:

[1] Task number in task group.

[2] Only the tasks with the largest positive and negative differences are listed.

[3] Average time per task for all subjects in minutes.

Table 6.16 : Differences between Computer and Manual Retrieval Times

No[1]	Task Description[2]	Time (min)[3]		
	CAPTURE	Comp	Manual	Difference
9	Add actions	2,14	0,51	1,63
3	Document problem status	2,45	1,15	1,30
5	Do progress notes	1,62	0,33	1,29

Notes to Table 6.17:

[1] Task number in task group.

[2] Only the tasks with the largest positive differences are listed.

[3] Average time per task for all subjects in minutes.

Table 6.17 : Differences between Computer and Manual Capture Times

6.2.11 Retrieval Errors

Table 6.18 shows how many information retrieval questions were answered incorrectly by the subjects using, respectively, the manual and computer systems.

No	Item		Subject								
			1	2	3	4	5	6	7	8	Avg
1	Manual Retrieval	Errors	5	4	4	6	6	4	3	5	4,63
2	Computer Retrieval	Errors	1	3	2	3	1	1	1	0	1,50

Table 6.18 : Retrieval Errors

6.2.12 Exit Interview

This is a summary of the exit interviews with the subjects:

6.2.12.1 Subject One

The subject feels threatened by the computer. Prefers the manual system to the computer system for his/her working environment in a black hospital. Is prepared to accept computer systems for a private practice or where a large number of patients are involved.

6.2.12.2 Subject Two

The subject sees a computer system as essential and accepts that computerized record systems will replace manual systems in future. Sees training to use the computer system as necessary. Had a positive experience of the experimental situation.

6.2.12.3 Subject Three

The subject prefers the manual system to the computer system. Experiences the computer system as threatening. Sees poor knowledge of computer system as a demotivating factor. Had a negative experience with the computer sessions. Doesn't see computer system as cost-effective.

6.2.12.4 Subject Four

The subject was ambivalent concerning the computer and manual system. Experienced experiment as positive, but mentioned lack of time to study manual properly. Sees computer as essential. Prefers computer system, but sees lack of knowledge as a problem.

6.2.12.5 Subject Five

The subject likes computers a lot. Prefers computer system to manual system. Feels that computers will be used more and more in future. Experienced experimental situation as positive. Enjoyed taking part in the experiment.

6.2.12.6 Subject Six

The subject prefers the computer system, but sees himself as too old for computers. Prefers computers for medical profession in general. For own purposes wants to learn

more about computers. Feels very positive about experiment. Pointed out that he has spent many years with a manual system.

6.2.12.7 Subject Seven

No data.

6.2.12.8 Subject Eight

The subject feels positive towards computer system, but sees room for improvement in training. Feels positive about experiment. Pointed out the advantages of a manual system and said that the needs of the medical profession should be taken into account at an earlier stage of the development process. Pointed out that both manual and computerized systems have their appropriate uses.

6.3 Interpretation

6.3.1 Introduction

As stated in Chapter One the study was undertaken to explore a methodology to evaluate user interaction with an interactive medical record system. Although there are too few subjects to come to any conclusion about the evaluation hypotheses, the results are repeated here for completeness sake. Because of the explorative nature of the investigation and the limited number of subjects, no statistical analysis of the significance of the results will be attempted. Refer to paragraphs 3.1.2 and 3.2.5.2 for a description of the hypotheses.

6.3.1.1 Hypothesis A

Five out of the eight subjects managed to successfully complete 80% of the benchmark set of tasks. An average score of 78,1% was reached by the subjects. This is an indication that the system is not too difficult to learn.

6.3.1.2 Hypothesis B

The computer system failed this test. The subjects spend 18% of the time during computer retrieval, making or correcting errors, and 13,1% of the time during computer capture. The results for the manual system were, respectively, 2,9% and 1,1%.

6.3.1.3 Hypothesis C

The error-free times for the computer system was on average longer than the times for the manual system. See Graphs 11 to 16 and the accompanying discussion.

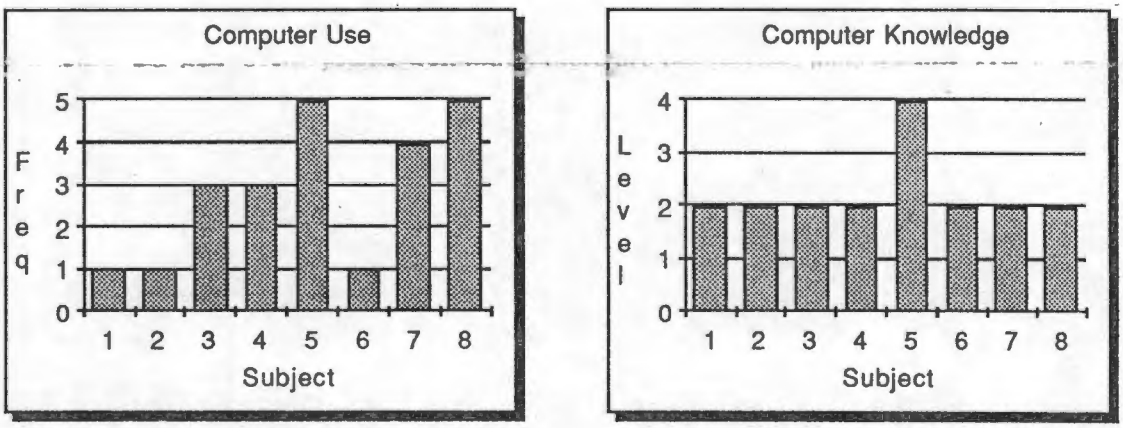
The subject on average experienced more problems using the computer system than using the manual system. See Graphs 17 to 22 and the accompanying discussion.

The use of the computer system resulted in less errors in answering the retrieval questions. See Graph 23 and the accompanying discussion.

6.3.2 Questionnaire

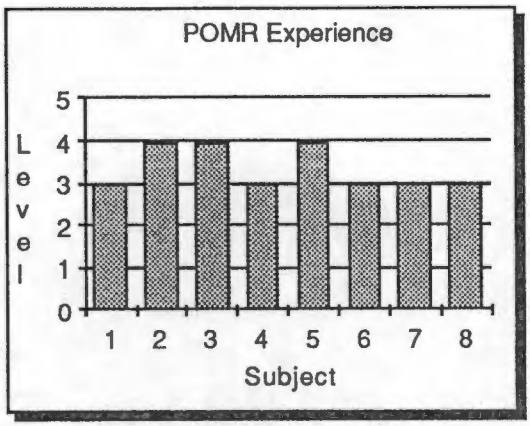
6.3.2.1 Experience

The subjects varied in their experience with computers. More than half used a computer system directly on a daily to monthly basis. It seems though that they use these systems without understanding the underlying aspects, because all, with the exception of one, state that their knowledge about computers is below average.



Graph 6.1 & 2 : Computer Use and Knowledge

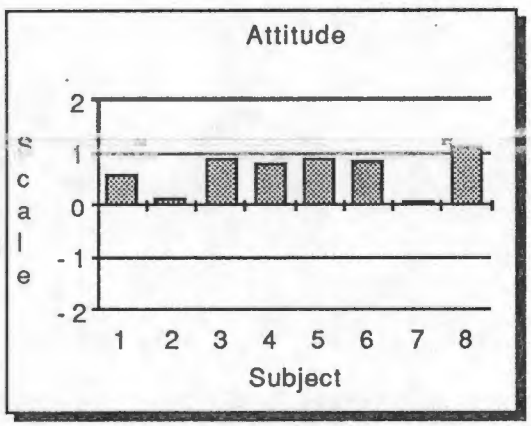
The subjects all consider the priority of computerization in medicine to be high. All of them are also prepared to enter their notes directly on computer. All of the subjects were familiar with the problem-oriented medical record.

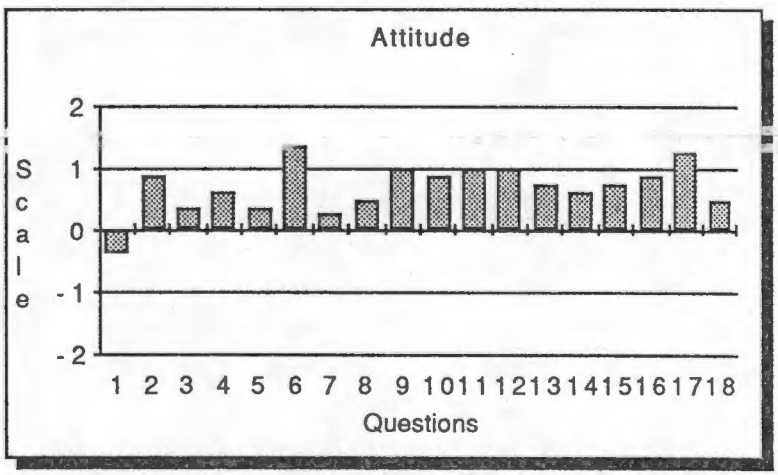


Graph 6.3 : Familiarity with POMR

6.3.2.2 Attitude

The attitudes of the subjects to computerized medical record systems were in general positive. The most negative attitudes concerned the danger of an increase in governmental control over physicians and the difficulty of learning to use a computer system.

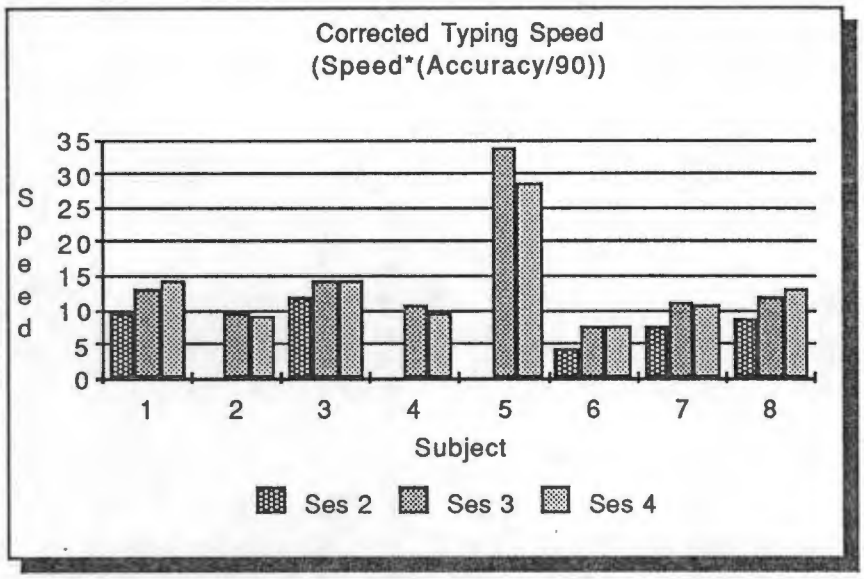




Graph 6.4 & 5 : Attitude to the computerization of medical records.

6.3.3 Typing Ability

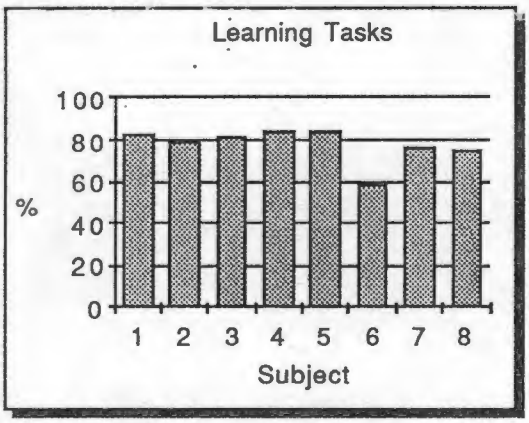
With the exception of one, all the subjects had limited typing skills. These skills improved through very simple training to a level where their typing skills were not a severe limitation in using the computer system. There was no marked deterioration in typing skills between the typing training and the final evaluation session.

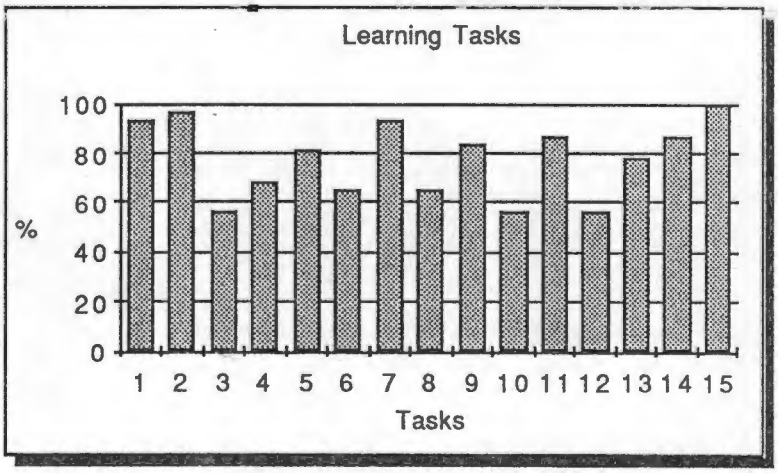


Graph 6.6 : Typing Skills

6.3.4 Learning

The average score was close to, but lower than the hypothesized level. (See Hypothesis A, paragraph 3.2.5.2.1). The three most difficult tasks were the creation of a contact (Progress Note), the repetition of previous medications and the selection of a subset of actions.

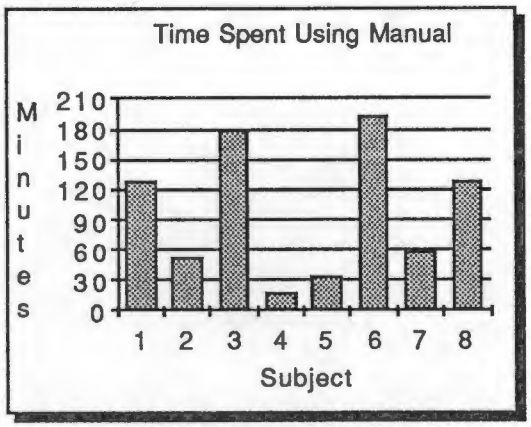


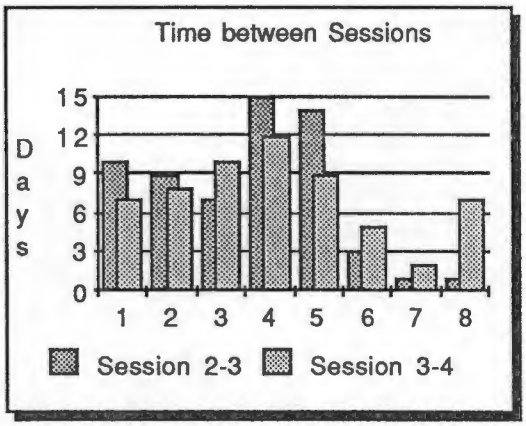


Graph 6.7 & 8 : Learning per subject and per task.

6.3.5 Use of Manual and Time between Sessions

Unfortunately there were great discrepancies between subjects on these variables. Especially the time between sessions should have been kept more constant, but this was difficult due to the busy schedule of the clinicians taking part in the study. The subjects were told to spend as much time as they thought necessary with the manual; individual variability is reflected in the recorded times.

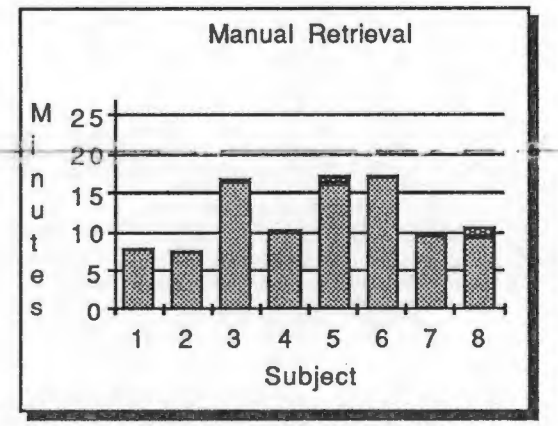


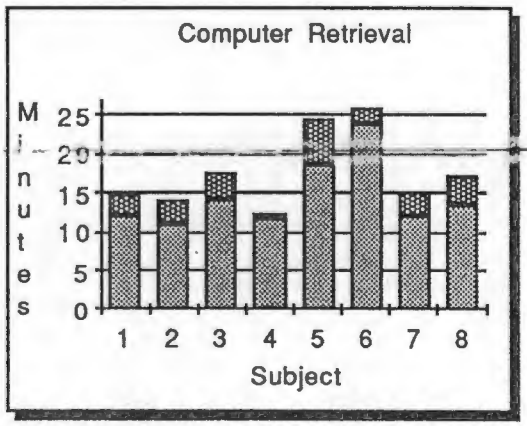


Graph 6.9 & 10 : Manual Use & Time between Sessions

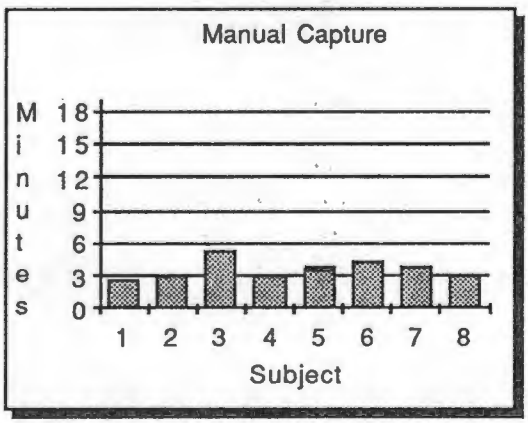
6.3.6 Task Performance

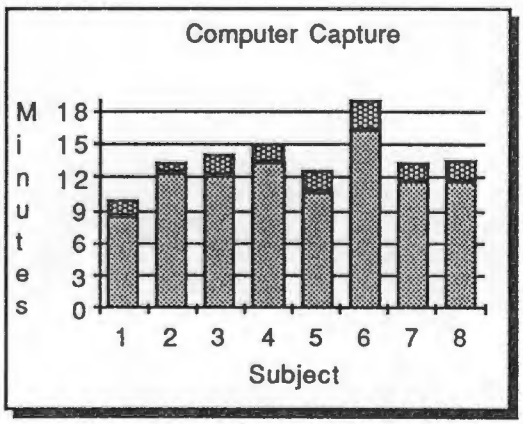
The subjects spent more time making errors and correcting those errors while using the computer system.





Graph 6.11 & 12 : Retrieval Task Times



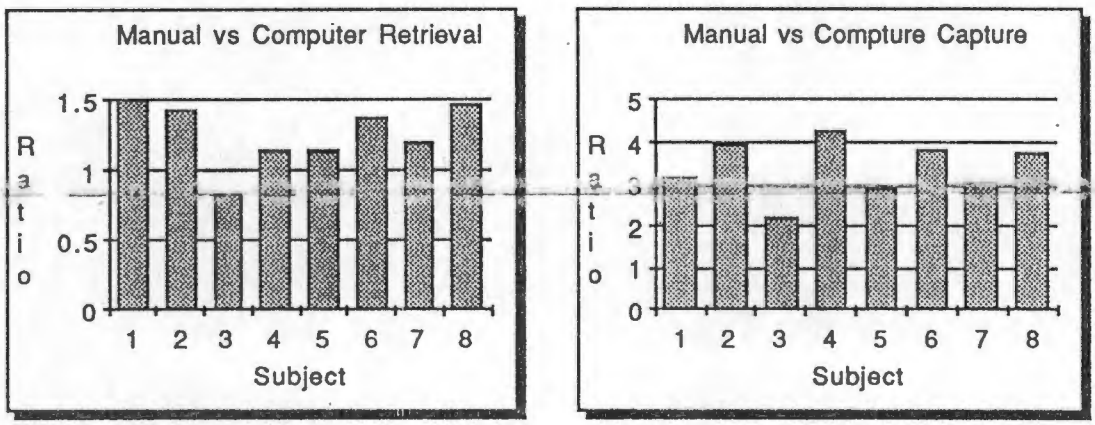


Graph 6.13 & 14 : Capture Task Times

The percentage of time spent with errors is higher than the hypothesized percentage of 5% (Hypothesis B, paragraph 3.2.5.2.1). The values from Table 6.5 are 18% and 13.1% respectively for retrieval and capture. The corresponding values for the manual system are 2.9% and 1.1% respectively. These are lower than the hypothesized value. The darker parts in the graphs indicate the error time.

Retrieval tasks were executed on average 1.34 times faster using the manual system. Capture tasks were executed 3.42 times faster on average with the manual system (Graphs 6.15 & 16). The graphs represent how much faster the manual system was compared to the computer system. A value of 2 on the vertical axis means that a subject was two times faster using the manual system as when using the computer system.

Evidence of order effects was observed with the first subject (No 3) during manual capture of the record. The subject remarked that the patient record appeared familiar. For this reason a different patient record (cf paragraph 3.2.4.4.6) was used for manual capture. Subsequently no additional order effects were observed.



Graph 6.15 & 16 : Comparison between Manual and Computer Systems

6.3.7 Problems

A total of 73 different problems were experienced by the subjects, while using the manual and computer systems. These 73 problems were manifested in 385 problem instances. Appendix B contains a complete list of all problems and specifies which problems occurred during particular tasks. To put the classification of the problems in context, it is suggested that the reader refer to this list of problems. The problems were classified into five groups. The first four groups correspond to the four levels of human-machine interaction (Foley 1980; Moran 1980), e.g.:

a. Lexical Level. User-system interaction must ultimately be resolved as a sequence of physical actions — key presses and other primitive device manipula-

tions. It also consists of the binding of these hardware capabilities to specific units of the output or input language.

b. Syntactic Level. The interaction with the system is imbedded in a language structure, the command language through which users communicate with the system. It establishes the sequence and context for the physical (lexical) actions.

c. Semantic Level. The interactive system is built around a set of objects and manipulations of these objects; to the user they are conceptual entities and conceptual operations on these entities. The semantic level represents the functionality of the system and specifies methods for accomplishing tasks in terms of these entities and operations. It has to do with the "meaning" and "functions" of the entities contained in the system.

d. Conceptual Level. Users come to a system with a set of tasks that they want to accomplish. The conceptual level of the interface structures the interface in such a way that it is amenable to the accomplishment of these tasks. It is the basic approach to how the system functions. Two conceptual models for the recording of medical record information, for example, are to use pen and paper, or to use a computer system. Within these two major conceptual models further conceptual approaches can well be distinguished.

With this classification in mind the problems were grouped as follows:

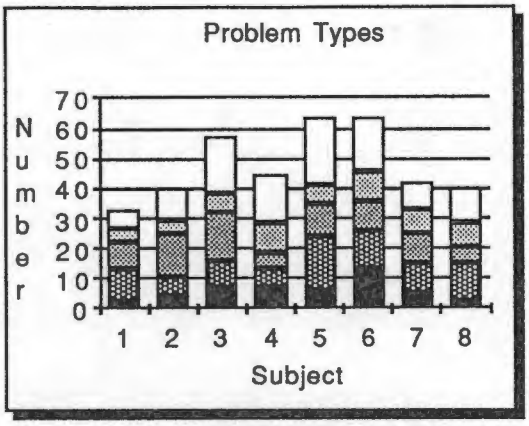
a. Lexical Problems. Problem or errors with the physical components of the interface.

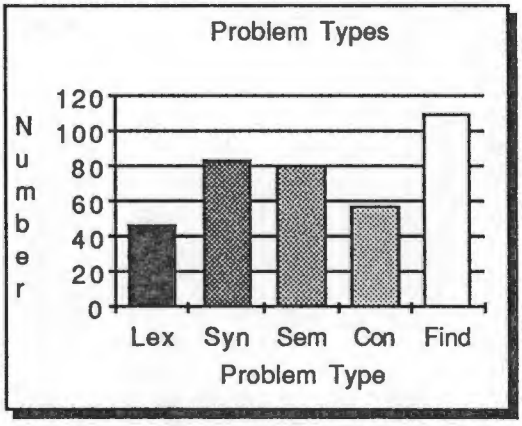
b. Syntactic Problems. Problems with or errors in the sequence of operations.

c. Semantic Problems. Difficulty with the meaning or function of an interface component.

d. Conceptual Problems. Difficulties with how to do a particular task.

e. Find Problems. After classifying the problems according to groups a to d, there were still a number of problems which could not be readily classified into any of these classes. On closer scrutiny these problems all had to do with finding or recognizing something, for example, finding a particular item in a displayed list.

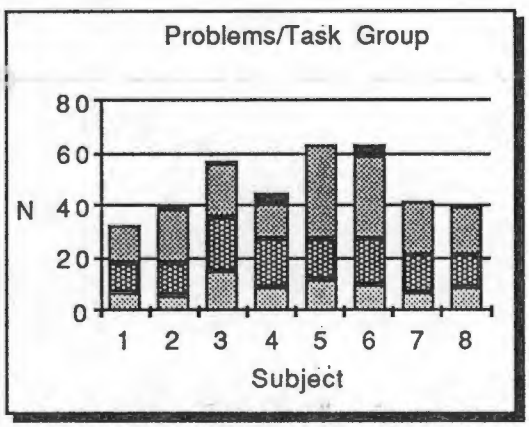


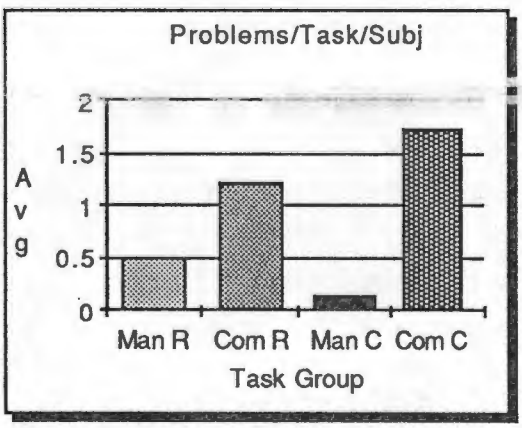


Graph 6.17 & 18 : Problem Types

The patterns in Graphs 17 and 18 correspond to the different types of problems.

The subjects experienced more problems with the computer system, and when we compare the average number of errors per task per subject, we find problems in particular with the capture of information on the computer system (Graph 6.20). The situation was different with the manual system where the subjects had more problems with the retrieval of information.

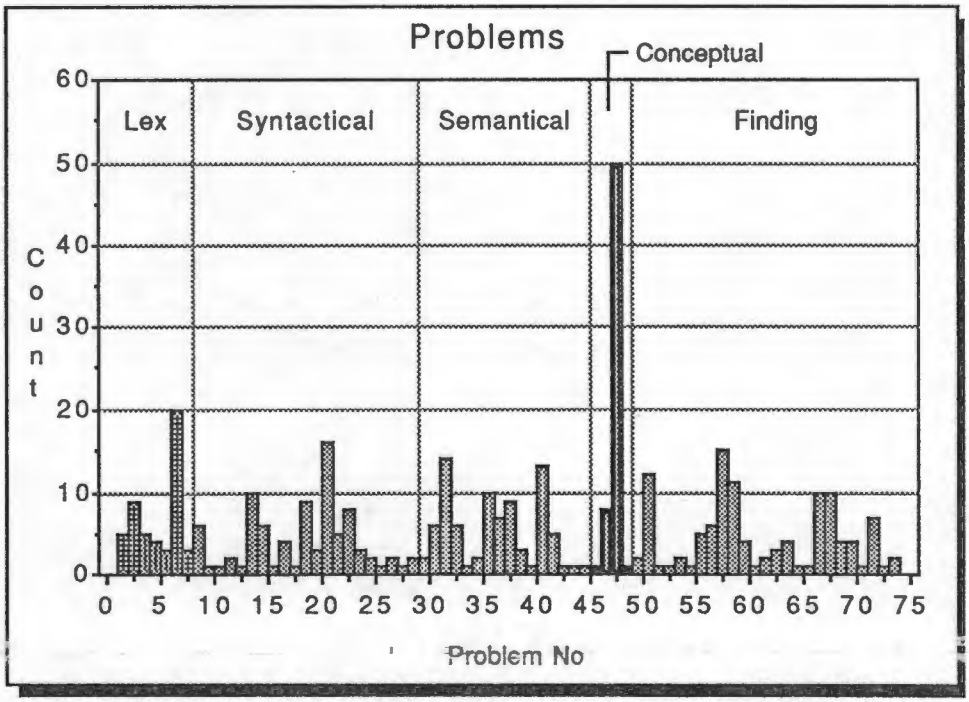




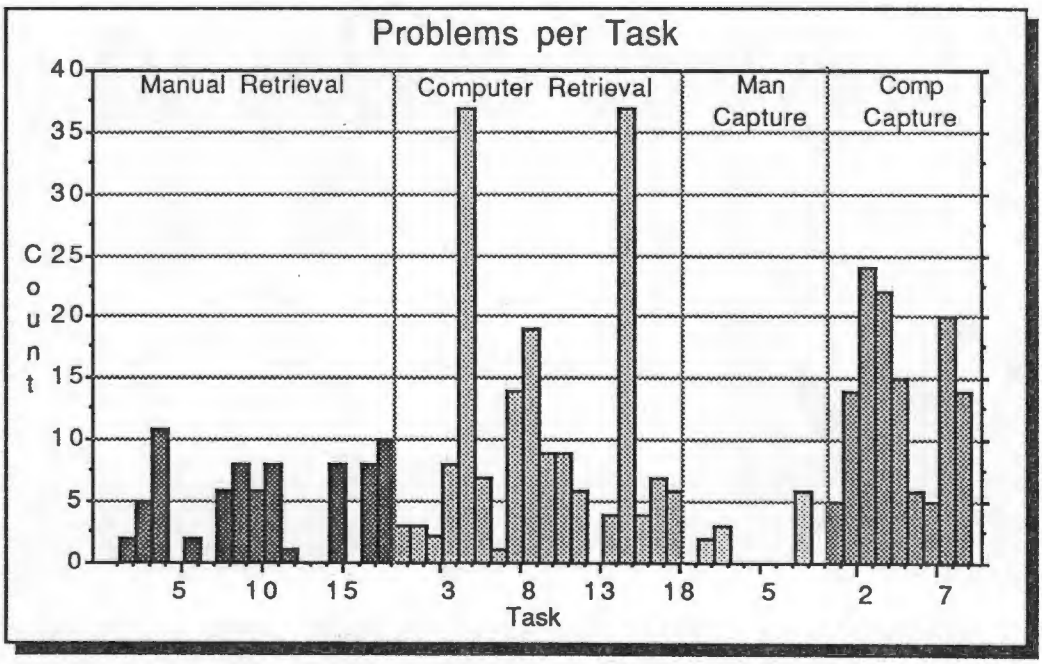
Graph 6.19 & 20 : Problems per Task

The most common problem with the computer system was that the subjects were unsure about the precise method to follow in order to accomplish a particular task. This conceptual problem was followed by a lexical problem with scrolling a window. The most common problem with the manual system was readability followed by difficulty with the interpretation of the conventions used in the manual system. Graph 6.21 gives an overview of the frequency of the various problems (For the numbering used, see Appendix B). Graph 6.22 gives an overview of the frequency of problems per task. The tasks which caused the most problems during manual retrieval are listed in Table 6.12. The most important of these was: To indicate when a particular problem was terminated and to count the number of referrals of

a particular kind. Of the computer retrieval tasks listed in Table 6.13, the tasks stating the problem status at a given date, and what happened to the patient when a particular medication was given resulted in the most problems. Note that the manual does not indicate how to do the first task, which probably explains the difficulty with this task. The most problematical of the computer capture tasks (Table 6.15) were the documentation problem status, addition of flow sheet entries, and repetition of an action.



Graph 6.21 : Problems



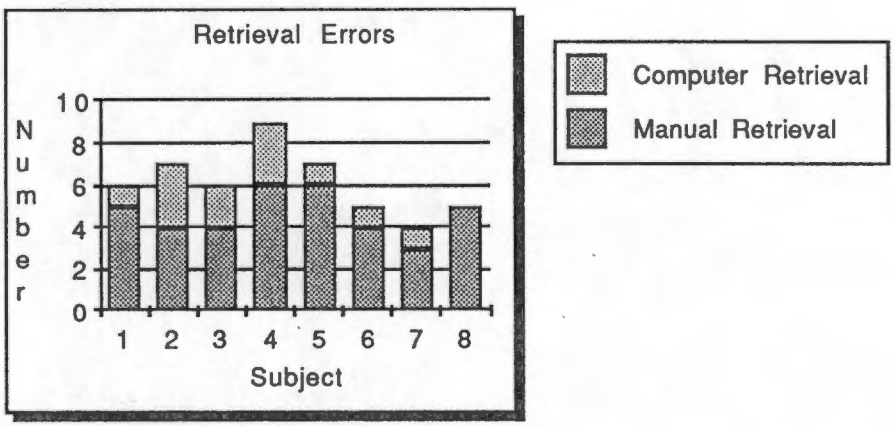
Graph 6.22 : Total Number of Problems per Task.

Contrary to the second part of Hypothesis C the subjects experienced on average more problems with the computer system than with the manual system.

6.3.8 Retrieval Errors

The subjects answered the questions more accurately when retrieving information from the computer record.

In accordance with the third part of Hypothesis C the subjects made less retrieval errors using the computer system.



Graph 6.23 : Retrieval Errors

CHAPTER SEVEN: CONCLUSIONS

7.1 Experimental Results

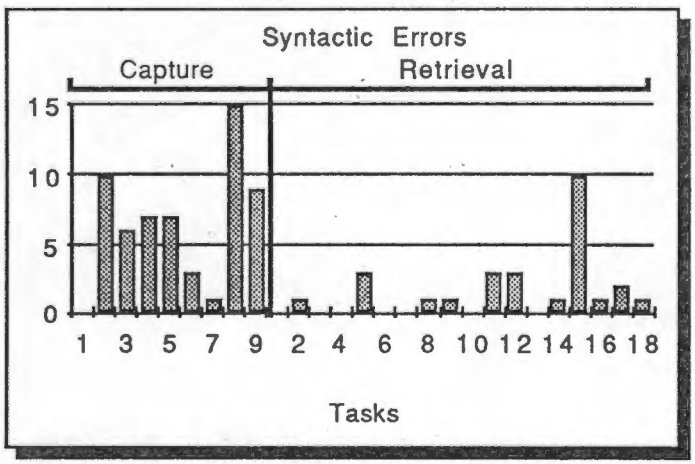
7.1.1 Attitudes

The limited number of subjects makes it difficult to come to any general conclusion about the attitude survey. One notable aspect is the attitude that computers will be difficult to learn and, with the exception of the attitude to increased control by government, the subjects scored the lowest on this item. It is possible that some of the resistance to computers (Barnett 1984) can be explained by this perception that computer systems are difficult to use. As one of the subjects put it in the exit interview "I have studied more than seven years to become a doctor, I don't see why I have to learn something totally new now to do my job". If an improvement in the learnability and usability of computerized medical record systems could be realized it might cause, as an important side-effect, a change in this perception and a more positive attitude to medical computer systems in general.

7.1.2 Typing Abilities

The important conclusion here is that limited typing abilities need not be a severe handicap in using an interactive computerized medical record system. Medical records with large amounts of free text notes, however, will be more problematical. In this respect it is important to design the system in such a way that the structure of the record itself will tend to reduce the length of free text notes. For example, the POMR compared to the traditional medical record (Rakel 1977, p437).

7.1.3 Learning



Graph 7.1: Practice Effects during Experiment.

The results of the evaluation as a whole should be seen in light of the fact that the subjects were not expert users of the computerized system. The subjective evidence for this is that the subjects received only two hours of training for the computer system. Objective evidence is more difficult to establish. According to Sheil (1981) one would expect to find evidence of practice effects during the experiment if the subjects were not experts in using the system. If one looks at the occurrence of syntactic problems in the progression of computer tasks, some evidence emerges of practice effects (Graph 7.1). Syntactic problems are chosen because they relate to the sequence of actions required to use the computer. One would expect to observe more marked differences here as the skill of the subject increases. The sudden increase in syntactic errors at retrieval task 15 ("What happened to problem after receiving medication") probably occurs because the subjects used the graph-drawing capabilities of the system here for the first time.

The fact that the computer system is observed during a learning phase introduces a number of difficulties in interpreting the evaluation results. For example, on average the subjects experienced more problems during computer capture (Table 6.9); this could be either because it was early in the experiment, or it could be that the capture tasks are intrinsically more difficult than the retrieval tasks. The preponderance of syntactic errors in the capture tasks argues for the first explanation, but the preponderance of conceptual problems for the latter.

The comparison of task times is complicated by the subjects not being experts in using the computer system. The subjects obviously took longer to execute the tasks on the unfamiliar computer system. It is impossible to say how much of this was due to lack of training and how much to the intrinsic difficulty of using a computer system. However, this effect cannot be avoided in a methodology designed for systems under development — by definition it is impossible to test expert subjects of a system that is still under development.

The above limitation can conceivably be an advantage, because with non-expert users difficulties in using the system will probably be exaggerated thereby helping to show areas for improvement. Expert users may also have found ways of working around limitations in the system, thereby causing these limitations to be less evident during evaluation. On the other hand though, the evaluation might not show aspects which could be frustrating for expert users, e.g. limitations in functionality or slow response times.

7.1.4 Time between Sessions

The time between sessions varied considerably between subjects, and constituted an additional source of variability between subjects and it should be kept more constant in subsequent studies.

7.1.5 Task Performance

Contrary to the hypothesis the computer system proved to be slower than the manual system. Capture tasks were particularly slow on the computer system. There is a rather small difference between the tasks times for computer and manual retrieval (Table 6.7 and Graph 5.15). Even though the subjects were not experts in using the computer system, they were on average only 1.34 times slower when using the computer system. A general contribution of this study is an approximation of the time ratios between comparable computer and manual systems. This was not generally available up to now. To come to a more definitive conclusion one would of course need a representative sample of expert users of both systems under consideration.

The only expert user of the computer system under consideration here is the developer. For interest's sake the developer was evaluated under the same circumstances as the experimental subjects. (The tasks and environment were the same, but the patient records and contents of the questions were independently set and asked). The developer was 1.4 times faster with computer retrieval compared to manual retrieval, and 1.72 faster with manual capture compared to computer capture.

The tasks which showed the greatest average difference in time between the manual and computer systems may indicate where the computer system might be improved (Tables 5.16 & 5.17). The differences in task times for tasks 5 and 15 can probably in part be explained by learning difficulties. The user manual did not give an example of how to determine the status of a problem on an arbitrary date. The task to determine what happened to a particular problem while the patient was receiving a specific medication was also difficult in its use of selections and graphs. Even with the learning effects taken into account, the computer support for task 5 can still be improved. In the manual system the task consists simply of paging to the progress notes for that date, looking at the problem list to determine the number of the problem of interest and then locating that number in problem status record in the progress notes. In the computer system the subject has to scroll to the desired contact (scrolling is a task they had difficulty with – Table 6.11), select that contact and then select "Show problem status" from the "View" menu, determine the number of the problem from the problem list, and finally locate the problem in the problem status display. This is a much more cumbersome procedure than the manual one. The system might be improved by changing this task to one where the subject selects the problem of interest, then chooses the menu item "Show problem status", and the system then displays a temporally ordered list giving the status of the problem over time. The user may then scroll in this list to locate the date of interest. In the manual system the link between progress notes and problem status is obvious (because it is recorded in close proximity). This link is not so obvious in the computer system; the user needs to be aware of the actual file structure.

The difference in time for task 8 ("Find statement x in the progress notes") could be due to a variety of factors. One could be limited functionality of the computer system; there is no command to search for a specified string in the progress notes. Some of the subjects in fact tried to issue such a command. Another reason is efficiency - it is faster to page through written notes and scan for a particular statement than to scroll on a computer screen and scan for a particular statement (Hulme 1985).

The retrieval tasks where the computer was faster are also quite interesting. In task 4 ("When was problem terminated") one can see the difference the mere presentation of data makes. The computer system lists the completion date on the same line as the problem description. In the manual system this is also the case, except that it is seldom filled in, and the subject then has to search through the progress notes to find where the problem was actually terminated. This difference in presentation can also be observed in Task 18 ("How many referrals of a certain kind were there"). Task 16 ("What was the change in problem status over time") is interesting in comparison to Task 15 (see above) which also involved the use of graphs but in this case was done considerably faster. The effect of practice during the experiment can again be observed here. One suspects that these are the tasks which will be executed considerably faster by expert users. The superiority of the computer system in showing trend information is illustrated here, especially if one takes into account that the errors in retrieval (Table 6.18) for the manual system were mainly situated in these tasks.

7.1.6 Problems

By looking at the list of problems experienced by the subjects, ways in which both the computer and the manual system can be improved become clear. This information is summarized in the tables contained in Appendix C.

The most common problem with the manual record (Table 6.10) was difficulty with readability of the record (Problem 57). This problem is particularly noticeable where different clinicians care for a patient and share the same medical record for the patient. This is normally the case in ambulatory clinics, and also the case for the sample records used in the experiment. Even though the subjects were familiar with the manual record they still had problems with the conventions used in the record (Problem 31). This is due mainly to idiosyncratic variations in the use of the manual system by the clinicians responsible for the original record. One aspect of the record format (Problem 58) was particularly problematical; When a medication is terminated the entry is crossed out on the summary list at the top of the page, but because there may be many progress note entries on a page it is not always clear exactly at which contact the medication was terminated.

The most common problem (Table 6.11) in using the computer was that the subjects were unsure of the method to use to accomplish the task (Problem 47). This was followed by difficulty with scrolling (Problem 6), one aspect of the Macintosh interface that requires rather precise control of the mouse, and on looking back was perhaps not adequately covered in the training. Problem 20 is interesting. On creating a new contact a window is opened into which progress notes may be entered. Although the window is opened an actual contact record is not created for the patient until the contact window is explicitly saved by a "Save"-command or the "Enter"-key is pressed, if this is not done continuing with the process of capturing the patient's record leads to problems at a later stage. The action of terminating a contact was not immediately obvious to the subjects. This difficulty was also observed during the learning phase (Table 6.5). This is clearly an aspect of the system that should be redesigned. Another aspect which also gave rise to problems is the interpretation of the "↑,↓,→" symbols used for the improvement, worsening, and no change of problems, respectively (Problem 30) and basically the same problem in the interpretation of the graph (Problem 35). Explicit descriptions should be used instead. The nature of these problems was particularly clear when viewing the video-tapes.

Another way of looking at the results is to look at the tasks with which the subjects had the most problems (Tables 6.12 to 6.15). With the manual record the problem in general was to find information, while difficulties in operating the system predominated in the computer system (Table 6.9). An example was the question on how many gastroscopies the patient had (Task R18, paragraph 3.2.3.1.1), while using the manual system the subjects invariably answered this question incorrectly and generally had problems with the format and clarity of the record (Appendix B 2.1.1.18). Using the computer system the question was relatively easy to answer, as reflected in the shorter time needed for this task using the computer (Table 6.16).

With the computer retrieval tasks it is generally the more complex tasks that gave the most difficulties. One improvement to the system which should be made is to bring the graph immediately to the front when the user gives the "Draw Graph"-command. Currently the graph is often obscured underneath other windows, leading to confusion on the part of the user. As far as computer capture is concerned the process for adding a contact should be improved. Task C8 provides an example of a small change to the program which can make a large difference in the ease of use of the system. On opening, the Flow Sheet window displays the topmost entries in the Flow Sheet; all of the subjects then tried to scroll to the bottom of the Flow Sheet to add an entry (Although the system will scroll automatically when given the command to add an entry). By simply having the window opened showing the last entries, this step may be avoided.

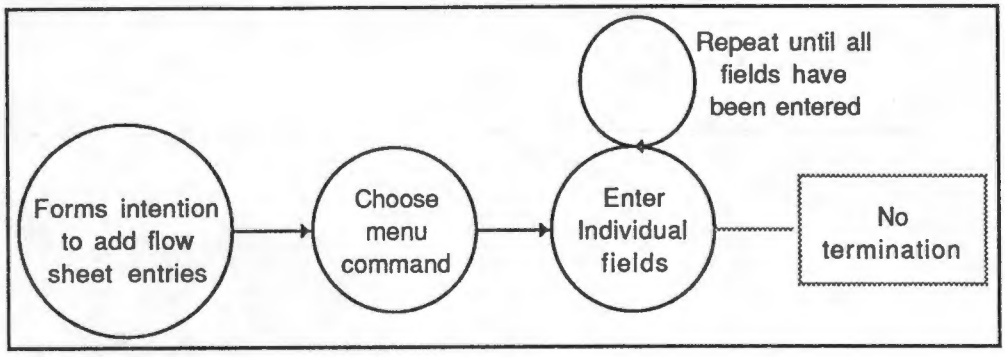


Figure 7.1: Flow Sheet Entry Task.

The importance of giving clear feedback to the user is also illustrated by this task (Task C8, Figure 7.1). When the user had completed the Flow Sheet entries, the appearance of the last cell entered is the same as the previous cells. Following this the subjects were confused, looking for something additional to do to complete the total process of entering values into the Flow Sheet. It is interesting to look at this particular problem in the light of Norman's (1984) theory of stages and levels in human-machine interaction. The user forms an intention to enter Flow Sheet values, say blood pressure and weight. The first action is to choose the menu command "Add Flow Sheet Entries". After the execution of this command the user can evaluate the outcome by seeing that an additional row has been added to the Flow Sheet with today's date. The actual values have not been entered yet, therefore the user forms a subintention to enter the blood pressure value; this leads to a series of actions resulting eventually in the value being displayed in the appropriate cell in the Flow Sheet, so providing the feedback that the series of actions to enter the blood pressure value have been executed successfully. The weight remains to be entered through the same process as the blood pressure. This series of actions is completed in the same way as for the blood pressure value, namely by pressing the "Enter"-key. As far as the system is concerned the user may stop at any stage and continue with something else. There is no specific indication that the total process of adding Flow Sheet entries has been completed. On the video-tapes one can observe that the subjects were confused at this stage – they were looking for something additional to do. This problem was termed "Difficulty with termination (20)" and could be observed in a number of other tasks as well. This problem is probably more common in direct interaction dialogues, where the user has greater freedom in interaction.

As far as the individual subjects are concerned, the large number of problems experienced by subject 5 is surprising in the light of the subject's previous experience with computers. One possible cause could be an interference between the subject's knowledge of other computer systems and IMIS. A similar effect has been described by Miller et al (1987) and they state

that direct manipulation interfaces are particularly prone to this effect. The preponderance of syntactic errors made by this subject might also be an indication of this.

The above is not an exhaustive description of the possible improvements which can be made based on the difficulties observed in using the system, but it gives an example of how one can proceed to derive useful information for the improvement of a system from the results of the evaluation. The tables in Appendix C summarize this information. It should be kept in mind that it is impossible to eliminate *all* errors, nor is it desirable to do so, because errors may be beneficial to the user, especially during learning. When the user is able to recognize the cause and carry out the correction of an error, errors may be highly informative (Arnold & Roe 1987).

7.1.7 Retrieval Errors

The fact that the subjects made fewer retrieval errors while using the computer system than when using the manual record is a potentially important result. With the amount of information available per patient increasing rapidly in modern medicine, this could be a contribution of computerized medical record systems to the improvement of clinical care. Due to the limited number of subjects and scope of the current project, a more detailed study looking at this finding is necessary.

7.2 Conclusions about the Evaluation Methodology

The test of the evaluation is whether it achieved the aim stated in Chapter One, paragraph 1.2. A look at paragraph 7.1 and at Appendix C would seem to show that it has been successful in this regard, and as such it is an addition to the tools available for the development of medical information systems.

As far as training is concerned, training in the basics of using the computer should be improved, particularly in the area of window manipulation and scrolling. Although not complete the training in using the system was probably sufficient for the subjects to use the system in a meaningful way to do the tasks set in the final session, and to provide information useful to improve the design of the system. If training is extended too far the methodology may become too difficult and time consuming to apply.

Currently the evaluation takes approximately four hours per person in training and experimental time with an additional three hours per person to analyze the video tape. The final session is particularly personnel intensive, requiring one person to ask the questions, a camera operator, sound engineer, camera mixer, producer and an additional person familiar with the experiment in the control room to assist the producer. A total of six people. At least

two persons are needed when viewing the video-tapes. The set-up for the final session can be considerably reduced by using only one portable video-camera and taping the video-output of the computer. This will eliminate the necessity of using a TV-studio. Under certain circumstances the video-camera may also be unnecessary, leaving only the video recording of the computer screen output and an audio recording of the questions asked and answers given. This minimum set-up will be particularly useful where the only interest is in the computer part of the interaction. With this set-up one person can easily handle the final session.

This modified instrument is described in Appendix E. In applying this instrument the following aspects should be taken into account:

a. Purpose. The instrument can be used to provide information to improve user-interaction with medical record systems. The instrument can also be used to compare user-interaction of different medical record systems. In this case subjects with sufficient expertise in using the systems should be selected. By changing the benchmark set of tasks, the instrument can conceivably be applied to the evaluation of systems other than medical record systems.

b. Cost. The modified instrument will be relatively cost effective. Video recorders able to record the composite video output of a terminal are relatively easy to come by. Portable video cameras are becoming cheaper and more available for use in more extensive evaluations.

c. Time. The evaluation is still quite time intensive. Two hours training time, one hour for the actual evaluation and between two and three hours for the analysis of results is needed to use the instrument. This gives a total amount of between five and six hours per subject evaluated.

d. Technical Expertise. No exceptional technical skills are needed during the training and experimental phases, other than a knowledge of the systems under investigation, and the ability to use a video recorder or portable video camera. During the analyses phase experience is needed to recognize and classify problems.

e. Evaluation of Results. The recognition of design improvements based on the results seems to be relatively easy.

An area which still needs more theoretical work is the description and classification of the problems experienced by the subjects in using the system. The list of problems is less helpful in helping to design new facilities for the system or new systems altogether. The problems are too specific to the system being studied. What is needed is a way of classi-

fying problems (errors) in such a way that the underlying causes/mechanisms of the errors become clear (Arnold & Roe 1987; Reason 1987). This should help designers to circumvent specific problems. Reason (1987) distinguishes between three levels of error taxonomies, namely behavioural, contextual and conceptual, which correspond approximately to the questions "What?", "How?", and "Why?". The taxonomy used in this work addresses the first level, the second to a limited extent and the third not at all. This third level will be of most use to designers but unfortunately also the most difficult to determine.

7.3 General Conclusions

Beyond the issue of an evaluation methodology to be used in the development of medical record systems, the work also provided some insights into the broader debate of computerized medical records as opposed to paper-based medical records.

a. The design of an adequate computerized medical record is a complicated process where many aspects must be considered. The way in which information is presented can make a big difference in the efficiency of using it. Problems experienced with the paper system we evaluated can be traced back in many instances to the poor representation of information which occurs in manual records.

b. The benefit of computerized systems in terms of more efficient and effective retrieval of information is not too difficult to obtain. The relatively simple computer system evaluated here shows decisive advantages in information retrieval compared to the manual system, but the addition of information to the record is still inefficient compared to a manual record. The improvement in information retrieval has to be paid for an increase in capture time. What remains to be shown is whether the medical profession will accept this additional time in order to improve their information retrieval capability.

c. The question of whether manual medical records can (or should) be replaced at all by computerized systems is still open. Based on this work it seems from an interaction point of view to be possible to improve the process of medical care (with the major impact on the retrieval and presentation of information). Our tools are still insufficient to answer this question in terms of the more important impact on the outcome of the clinical process.

7.4 Future Work

7.4.1 New Experimental Set-up

As noted in paragraph 7.1.2 the methodology can be simplified. A description of the simplified methodology is given in Appendix E. Paragraph 7.1.3b mentions the trade-off between retrieval and capture in a computerized medical record system. It would be interesting to use such a simplified methodology to compare two systems: one where the clinician is responsible for the capture of the information to another where the capture of information is done by a data typist.

7.4.2 Retrieval Errors in Manual and Computerized Systems

More detailed work is needed to study the increase in errors in information retrieval observed during the use of the manual record.

7.4.3 Problem Classification

Improved classification of the problems observed in the use of the systems may lead to a better understanding of the causes of these problems. This in turn will be very useful in the design of improved medical information systems. More information for the classification of the problems may be obtained by asking the user to comment on his/her problems while viewing the video recording shortly after making the recording, also known as "video self-confrontation" (Moll 1987).

IMIS USER MANUAL

Section One : Introducing IMIS

1.1 Background

This application, called IMIS (Interactive Medical Information System), was developed as an experimental system in order to compare the efficiency of a computerized medical record system with the efficiency of a manual medical record system. IMIS has been carefully designed to be as easy to use as possible, but to deliver the same functionality as a manual medical record.

IMIS follows the problem-oriented approach to medical record keeping and is closely based on a manual problem-oriented medical record that has been in use for several years at the Family Medicine Department of HF Verwoerd Hospital in Pretoria.

IMIS runs on a Apple Macintosh™ computer with at least 512K of memory and a hard disk drive.

To be able to use IMIS you should be familiar with the problem-oriented approach to medical record-keeping as described by Weed. Familiarity with the manual medical record used at the Family Medicine Department of HF Verwoerd Hospital would be helpful, but not essential. You should also be familiar with the operating concepts of the Macintosh™ and be able to type at least 10 words per minute with a 90% accuracy.

1.2 What IMIS can do

IMIS replaces the paper medical record of a patient. The doctor using IMIS will therefore enter his/her notes directly on computer while he/she is seeing the patient. If previous notes of the patient have been captured on computer, information can also be retrieved from the computer while you are seeing the patient.

As previously mentioned IMIS implements the problem-oriented model of medical record-keeping. All the familiar components of this model can be found in IMIS (Figure 1):

a. Baseline. This is a detailed record of the patient's condition at a particular time. This is normally done at the first visit, but can be repeated if necessary. The baseline investigation is also known as the "data base" in Weed's terminology.

b. Problem List. This is the most important single ingredient of the problem oriented medical record (POMR). A problem is anything that requires diagnosis or management or interferes with quality of life as perceived by the patient.

c. Progress Notes. Progress notes are made at each contact (consultation) with the patient. No structure is imposed on these notes by the system, and the user is free to use any format that he is familiar with.

d. Action List. This list is primarily used to keep tract of all medications given to a patient, but can also be used to record other actions, such as patient education, minor surgery, etc.

e. Flow Sheets. Flow Sheets are used to keep tract of values such as blood pressure, weight or laboratory tests such as fasting blood sugar.

f. Referral List. The referral list keeps a record of all referrals made for the patient. The actual referral report is not kept on the system. Positive findings are normally summarized in the progress notes.

g. Problem Status. The status of a problem is recorded at each contact (consultation). The status of a problem indicates whether a particular problem has improved, stayed the same, worsened, or has been resolved (terminated) since the last contact.

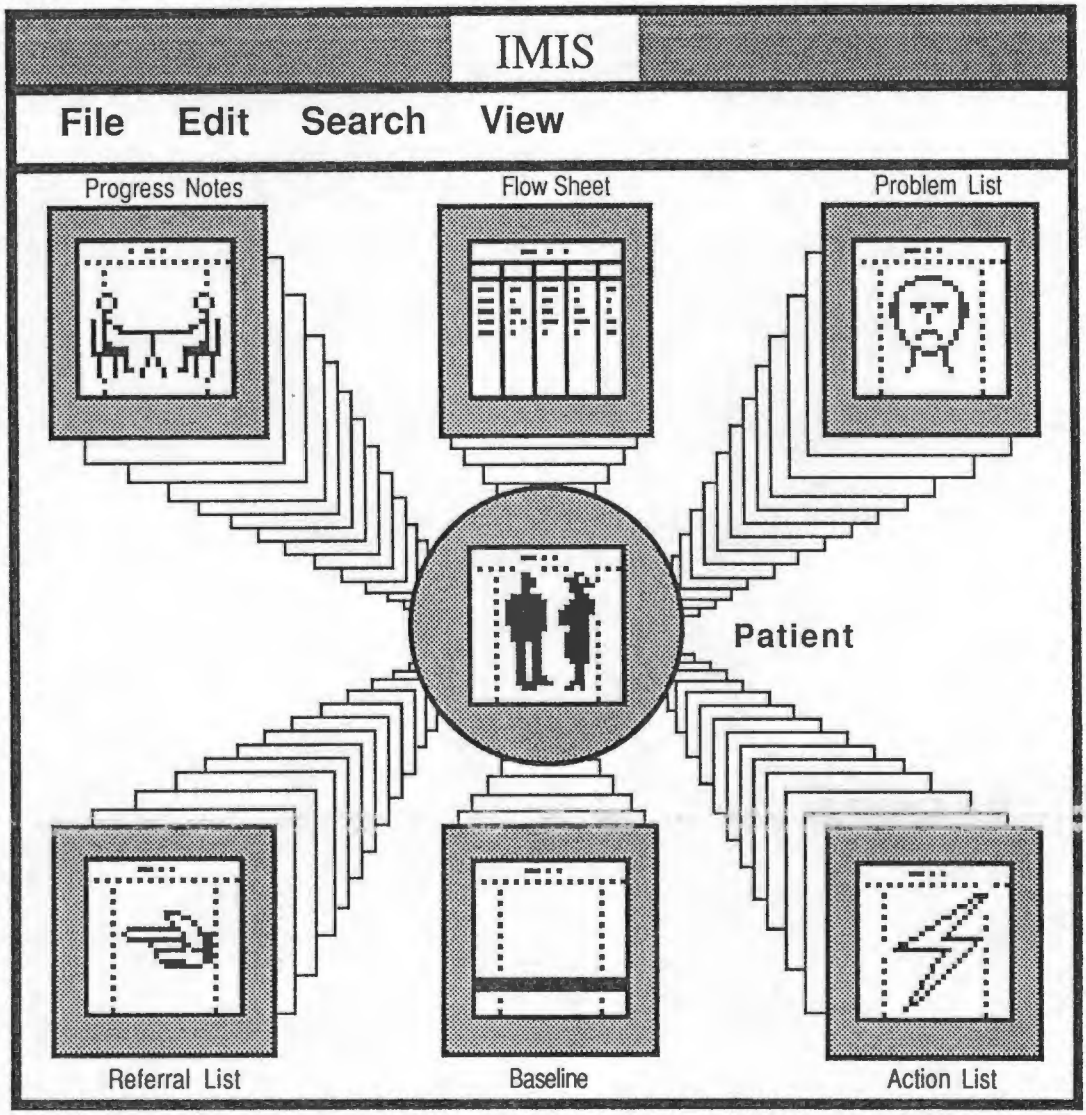


Figure 1. Conceptual Model

These components of the record can be acted on by the command groups listed at the top of Figure 1:

a. File. The commands in this group will allow you to add instances (records) of the components listed above, to the patient's record. The file of a patient can also be opened and closed using commands in this group.

b. Edit. Existing records can be changed or deleted by using commands in this group.

c. Search. Records satisfying certain criteria can be searched for and displayed using commands in this group.

d. View. Special components of the patient's record can be viewed by this command, eg problem status and graphs.

1.3.2 Adding a patient

Because this is the first time that we have seen patient R Jones, we shall need to add her to our list of patients (Figure 4).

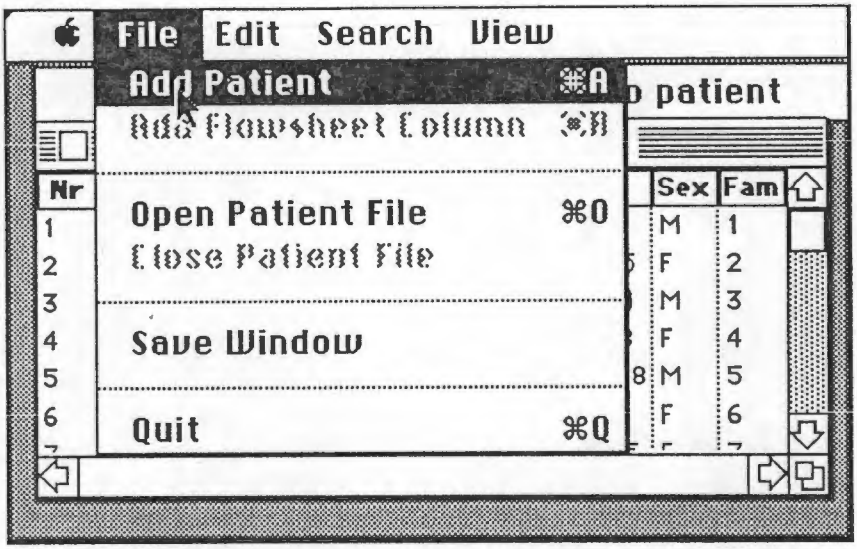


Figure 4: Adding a patient.

To add a patient we choose the item "Add Patient" from the "File" menu. This will cause the dialogue box shown in Figure 5 to appear.

Completing this dialogue box is very similar to filling in a form. The appropriate information is typed into the rectangles next to each field description. Eg. The patient's surname "Jones" is typed into the rectangle to the right of the field description "Surname". The field in which the typed letters will appear is shown by a flashing vertical line, as can be seen in the "Surname" field. This field is called the "active field". The current active field can be changed to another field by pressing the "Tab"-key or by clicking in the field rectangle. The letters "DD/MM/YY" in the "Birth Date" field is called a "Date Template" and is there to remind you of the format in which dates should be entered into dialogue boxes. The date "3 February 1985" should be typed as "3/2/85". Figure 6 shows the dialogue box as it should look like after our patient's details have been entered.

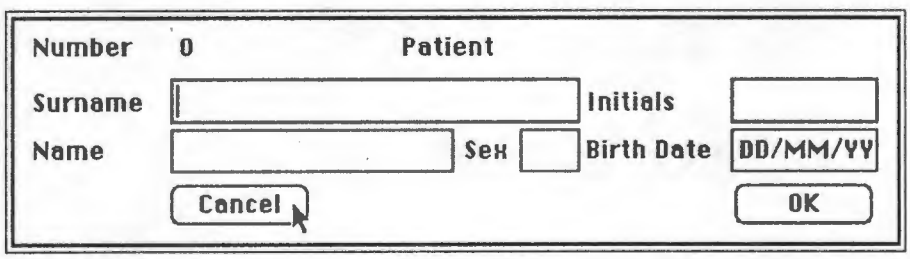


Figure 5: Add Patient Dialogue.

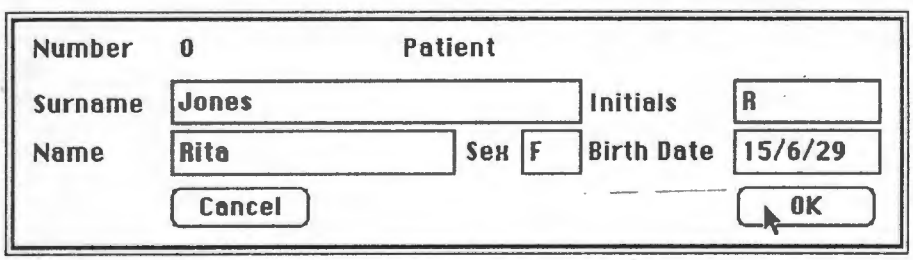


Figure 6: Completed Patient Dialogue Box.

The filling in of the dialogue box is completed by clicking in the rectangle labeled "OK". If you change your mind about adding the patient you can click in the rectangle labeled "Cancel" and you will return to where you were as if nothing happened. Upon clicking "OK" the "Patient Identification" window will reappear, but will now contain the details of the newly added patient (Figure 7). Our patient is numbered 28, this means simply that it is the 28th patient that was added to list of patients known to the system. Notice that patient Jones's details is written in white on black. This means that patient Jones is currently "selected". The selection of entries or records is something that you will deal with frequently. A record is selected by placing the "cursor" (The crosslike object in Figure 7) with the mouse over the record and clicking (pressing and releasing the mouse button in quick succession) the mouse. If you click on a record that is already selected, the same dialogue box as the one used to add the record will appear again (Figure 6) and you can then change the fields of the record.

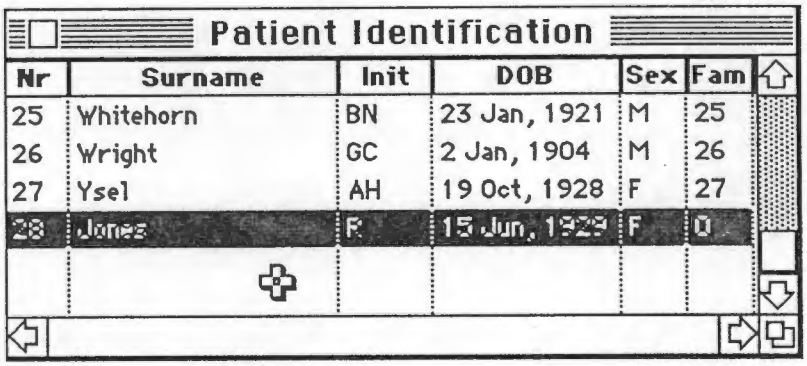


Figure 7: Patient Identification Window with newly added patient.

We have now successfully added a patient to our list of patients.

1.3.3 Opening the patient's file

The next thing to do is to open the patient's file, so that we can start entering information in it. To open a patient's file, select the patient (Figure 7) and then choose "Open Patient File" from the "File" menu. (Figure 8)

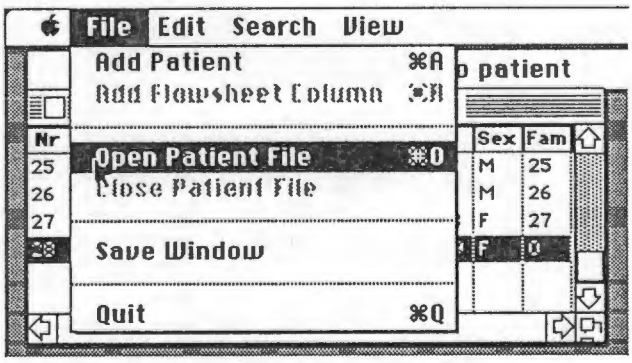


Figure 8: Open patient file.

After choosing the menu item you will be presented with a screen similar to Figure 9. From this screen you can access the complete record of the patient. All the information will be applicable only to the patient you have selected. To remind you of that, the patient's name, age and sex are displayed in a small window just below the menu bar (Figure 9). On opening the patient's file the "Progress Notes" window is automatically opened for you, showing the previous contacts with the patient. In our case none are shown because this is the patient's first visit.

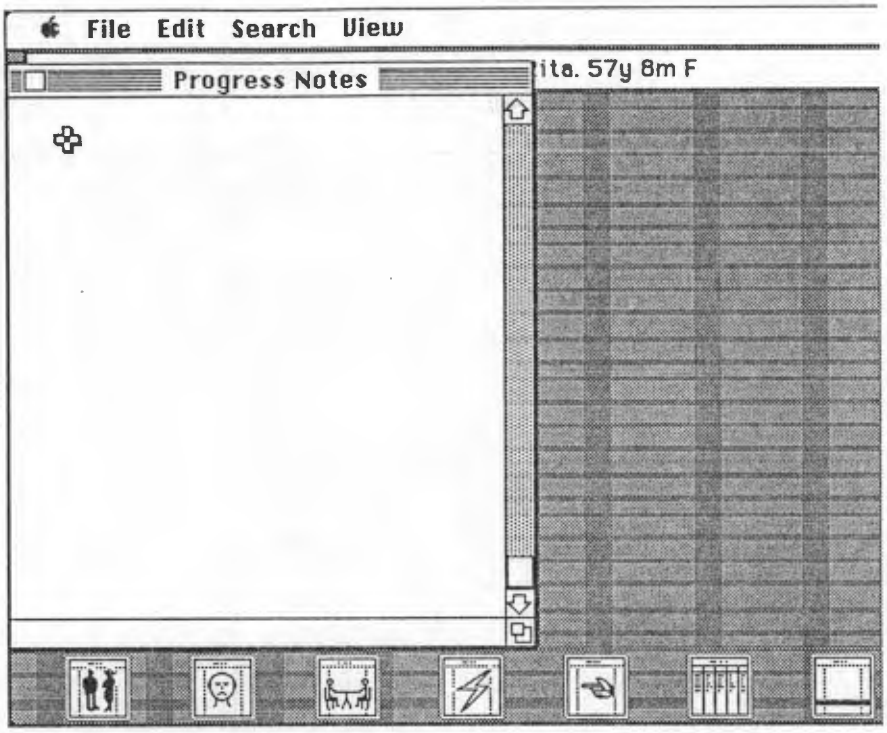


Figure 9: Display on opening a patient's file.

1.3.4 Capturing baseline information.

The baseline information consists of four separate sections:

a. General Clinical Questionnaire (Figure 10)

b. Systematic Clinical Questionnaire (Figure 12)

c. Systematic Examination (Figure 13)

d. Miscellaneous Data (Figure 14)

To display the baseline window, click on the rightmost icon. The baseline window will open. You will notice that this window is probably obscured behind the "Progress Notes" window. To bring the baseline window to the front click again on the baseline icon. The baseline window will now become the active window. The active window can be distinguished from the other inactive windows by the lines in its title bar and by the fact that it is the frontmost window. Actions will always be restricted to the active window. The screen should now look like Figure 10. Notice the extra menu in the menu bar, this menu is used to move between the sections of the baseline information. A baseline window is divided into four parts.

The first part is just below the window title and contains the date, baseline number and a scroll control. Todays date are entered by default into this field, but it can be changed. There can be more than one baseline investigation and the number indicates which one we are currently looking at. The scroll control allows you to scroll through these baseline investigations, by clicking in the arrows with the mouse.

The second part is just below the heading "General Questions" and contains a numbered list of questions.

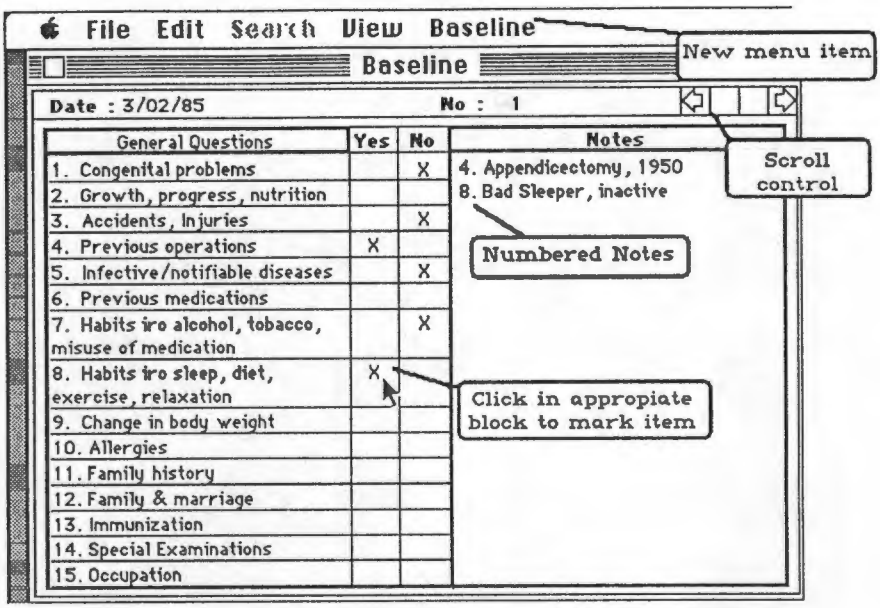


Figure 10: Baseline Window

The third part is the two columns titled "Yes" and "No". By clicking in either one of these columns, opposite a question, you can mark a question as being either positive or negative. To unmark a question, keep the "shift" key depressed while clicking on the mark.

The fourth part is a space where notes can be made to further expand on the questions in part one. These notes are normally numbered with the corresponding question's number.

To move to another section of the baseline investigation, choose it from the "Baseline" menu (Figure 11). To proceed, hide the Baseline window by clicking in the little square ("close box") in the left hand side of the title bar.

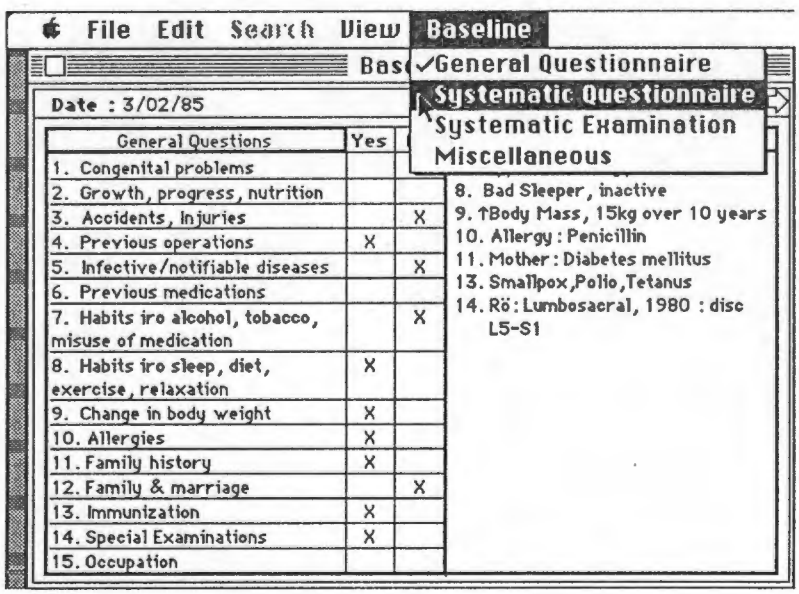


Figure 11: Choosing another section of the Baseline Investigation.

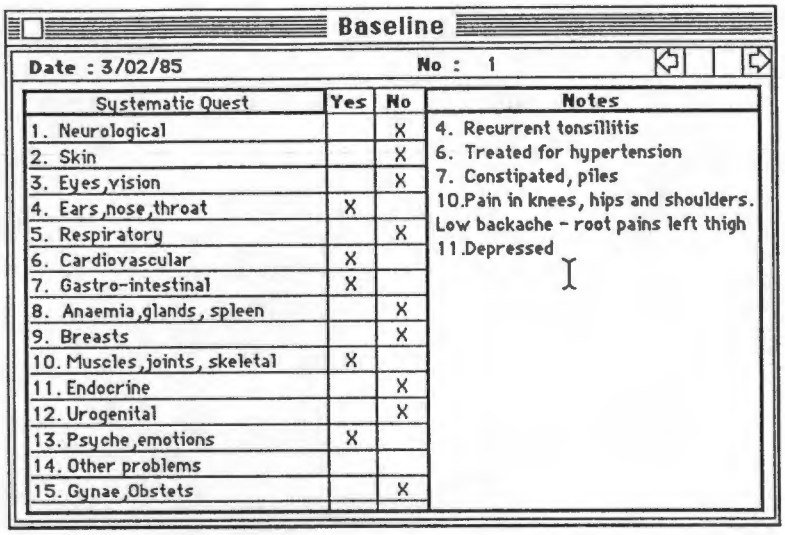


Figure 12: Systematic Questionnaire.

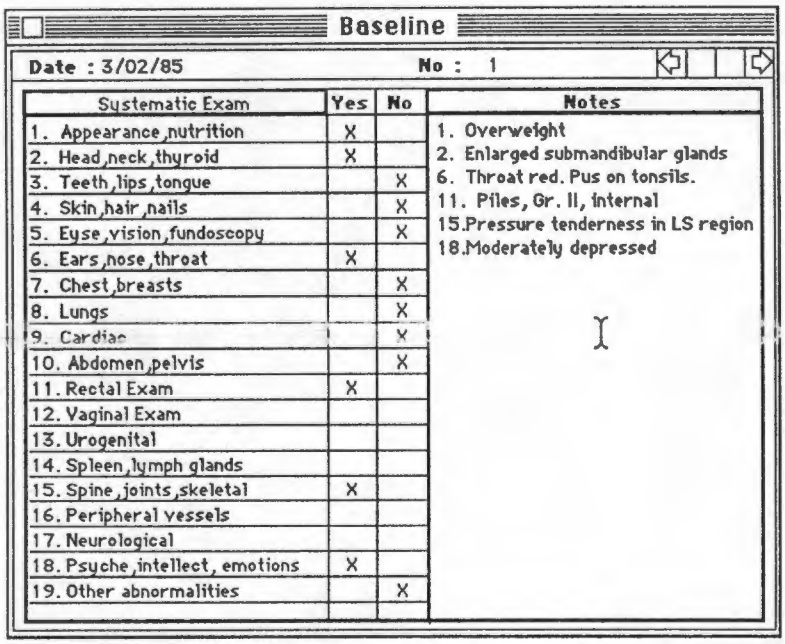


Figure 13: Systematic Examination.

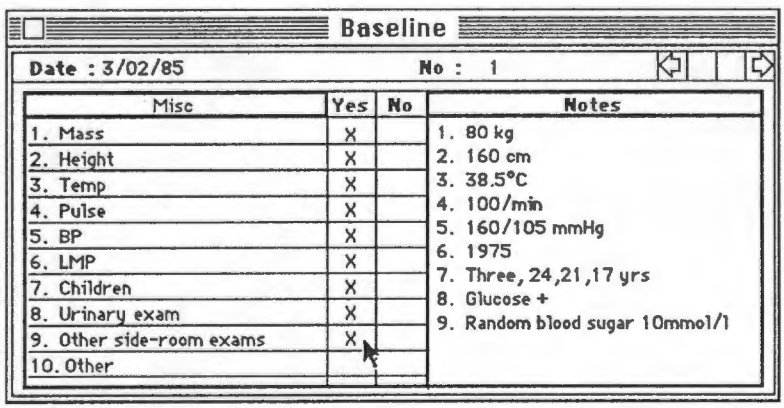


Figure 14: Miscellaneous information.

1.3.5 Adding a Contact

We are now ready to document our first contact with the patient. We do this by capturing a progress note. It is important to note that a progress note must be captured for every contact with the patient, even if no notes will be made. This must be done because the progress note contains important information about the contact, notably when it took place.

To activate the "Progress Notes" window click twice on the "Progress Notes" icon at the bottom of the screen. (That is the icon third from left, showing two people sitting at a table). Choose "Add contact" from the "File" menu to add a progress note for this contact with the patient. (Figure 15)

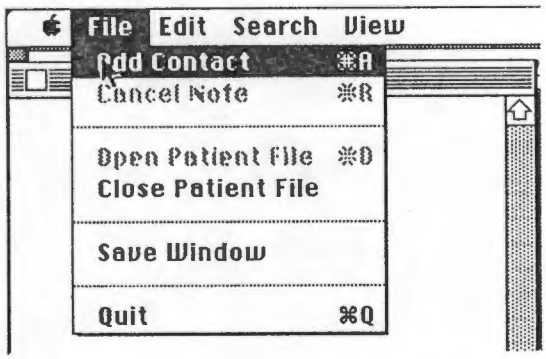


Figure 15: Add contact.

A small window will now be displayed on the screen (Figure 16). Enter any notes you wish to make into this window (Figure 17). For our example patient we shall enter the major complaint, diagnosis, and plan. Notes can be entered in any format. Todays date is displayed by default at the top of the window, this date can be changed by clicking on the date and then editing it in the normal fashion. On completion press the "Enter" key. The text you have just entered will appear in the "Progress Notes" window (Figure 18).

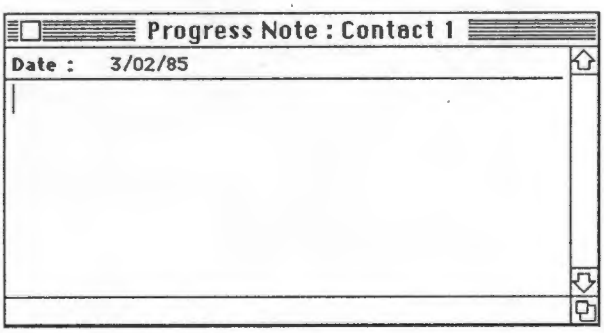


Figure 16: Progress Note window.

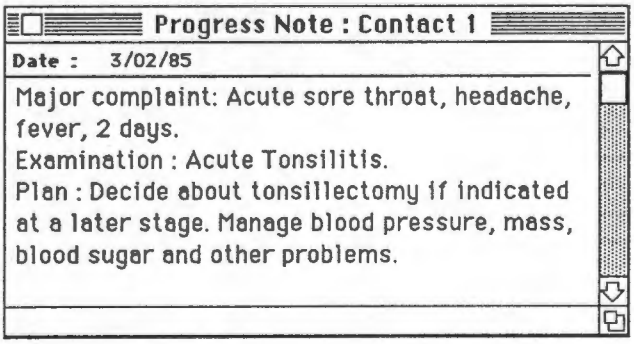


Figure 17: Window with notes entered for contact 1.

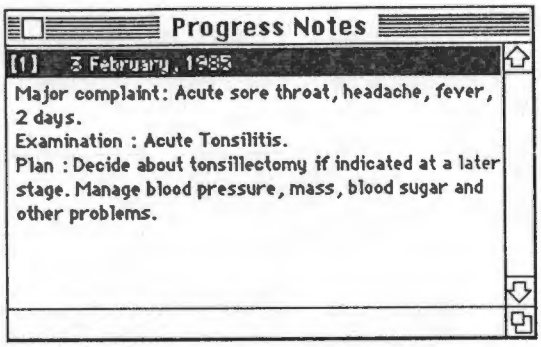


Figure 18: Notes as displayed in the progress notes window.

1.3.6 Adding a problem to the Problem List.

We are going to add the problem "Overweight" to our patient's problem list. The first step is to display the "Problem List" window and to make it the active window. We can do this by clicking twice on the "Problem List" icon. (That is the icon second from left, showing the sad face).

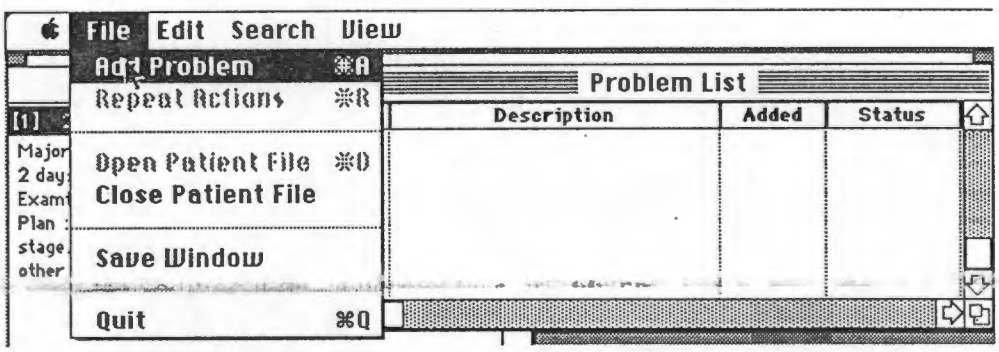


Figure 19: Adding a Problem List Item.

Once we have done that, the "Add Problem" item on the "File" menu (Figure 19) is chosen to display the "Problem List" dialogue box (Figure 20).

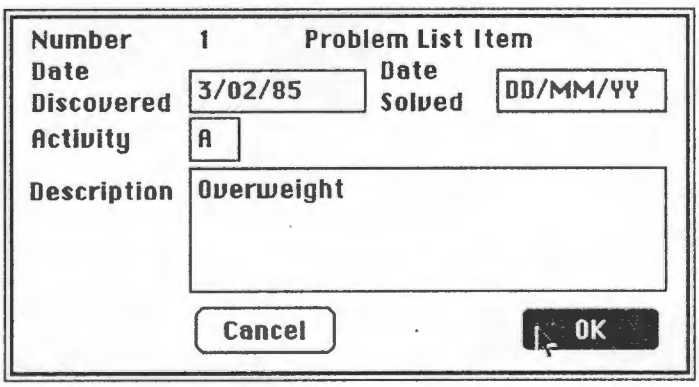


Figure 20: Problem List dialogue box.

Today's date is automatically entered in the "Date discovered" field, but it can be changed if necessary. If the problem is still present, the date on which it will be solved is normally not known, therefore the "Date solved" field is left as is. The activity of the problem is recorded in the "Activity" field. An "A" is entered for an active problem and an "I" for an inactive problem. A short description of the problem is entered in the "Description" field. On completion click on the "OK" button to record the information in the "Problem List" window. If you have made a mistake click twice on the problem

that you have added and the "Problem List" dialogue box will be displayed again and you can then correct the mistake.

1.3.7 Adding an Action to the Action List.

We are going to record the patient's treatment on the action list. The prescription is: X-mycin 500mg bd, Painkill 2 tablets for pain, 4000kJ diabetic diet, suppositories for piles, Rumagesic 2 at night.

By now you should have the general idea on how to go about adding these medications to the action list:

a. Double click on the "Action" icon (The icon fourth from left, depicting a lightning bolt), this action will display the "Action" window and make it the active window.

b. Choose the "Add Action" item from the "File" menu (Figure 21).

c. Complete the "Action" dialogue box (Figure 22).

d. Click on the "OK" button in the "Action" dialogue box.

As is normally the case todays date has already been entered into the "Date started" field (Figure 22). This date can be changed if necessary.

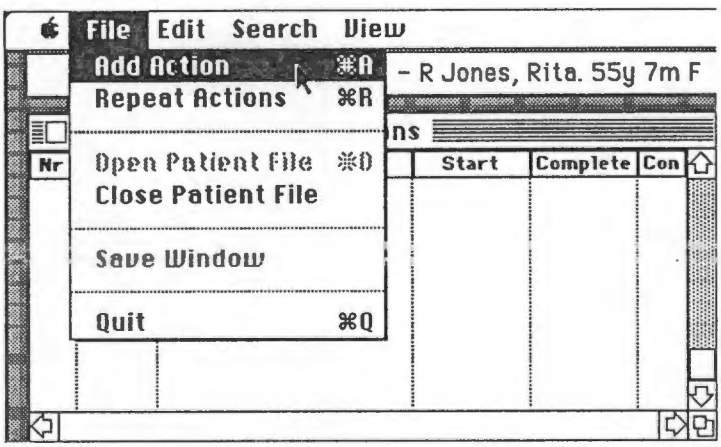


Figure 21: Adding an action to the Action List.

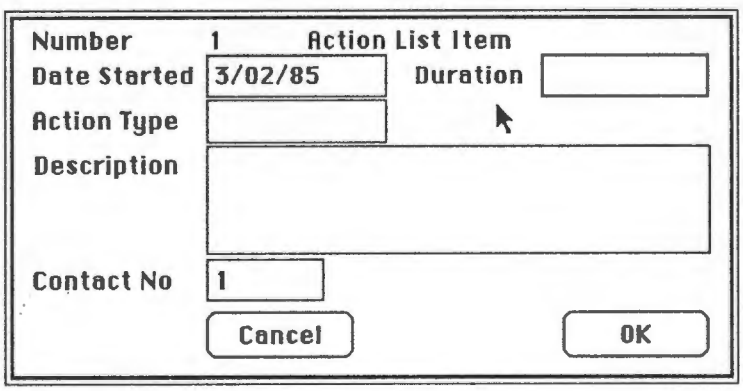


Figure 22: Action List dialogue box.

The duration of the therapy is entered in the "Duration" field. There are a number of ways in which you can enter this information:

a. Entering a number — duration in days.

b. A number followed by a "W" — duration in weeks.

c. A number followed by a "M" — duration in months.

d. A date — until that date.

e. A "T" — until today. (useful for "stat" treatments).

f. A "?" — until an unknown date in the future.

A code indicating the type of action must be entered in the "Action type" field. These codes represent a broad pharmacological classification of medications as well as a number of additional codes for actions other than medicines. If you do not know the code for a particular medication type a question mark ("?"). A list of available codes will then be displayed. (Figure 23). Select the code you want and click in the "Select" button. (Figure 23). In our case we are in the process of entering "X-mycin", so we chose "ERYTH" for "Erythromycin" as our action code.

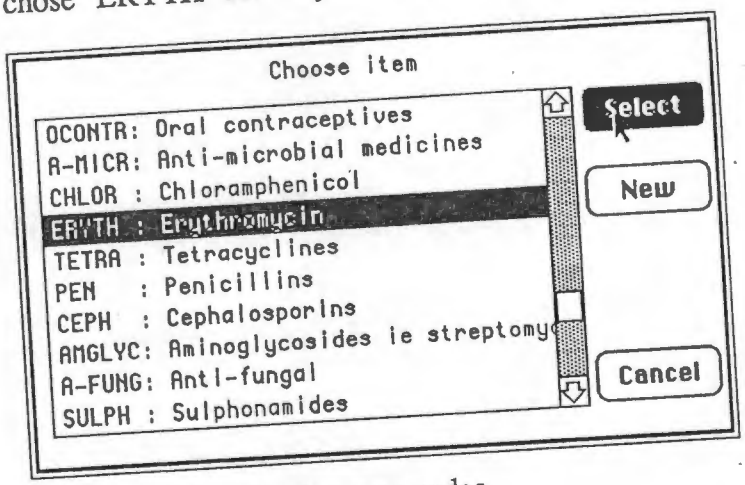


Figure 23: List of action type codes.

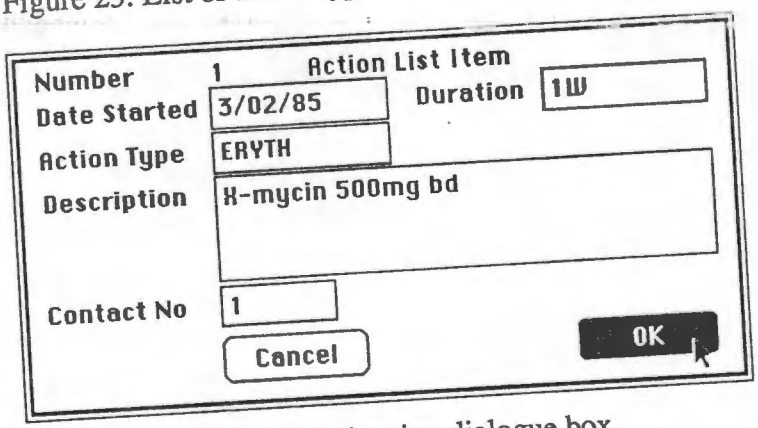


Figure 24: The completed action dialogue box.

In the "Description" we will enter a short description of the drug and its dosage. The "Contact" field has already been filled in with the number of the current contact, if necessary this number can be changed. Figure 24 shows the completed dialogue box.

It is not necessary to re-enter medications that are repeated at a later visit. Say our patient returns at a later date and we want to repeat all medications except the diet, we can do so easily by selecting (Figure 25) the medications we want to repeat and then choosing the "Repeat actions" item from the "File" menu. (Figure 26). To select more than one action you have to select the first action in the normal way, by clicking on the action, then to add additional actions to the selection hold the "Shift" key down while clicking on the subsequent actions.

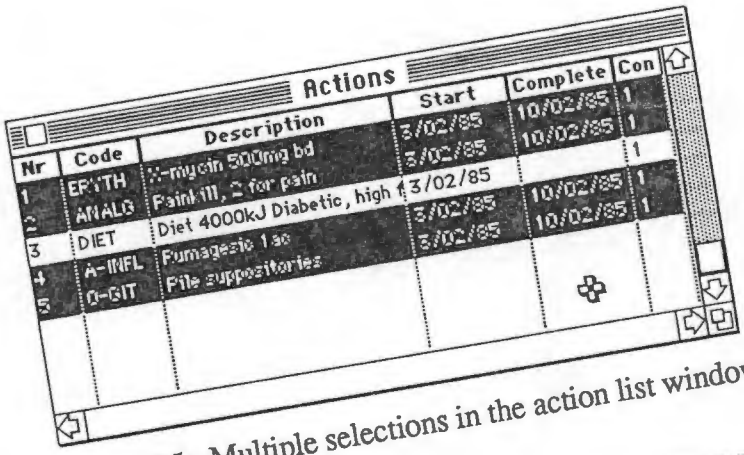


Figure 25: Multiple selections in the action list window.

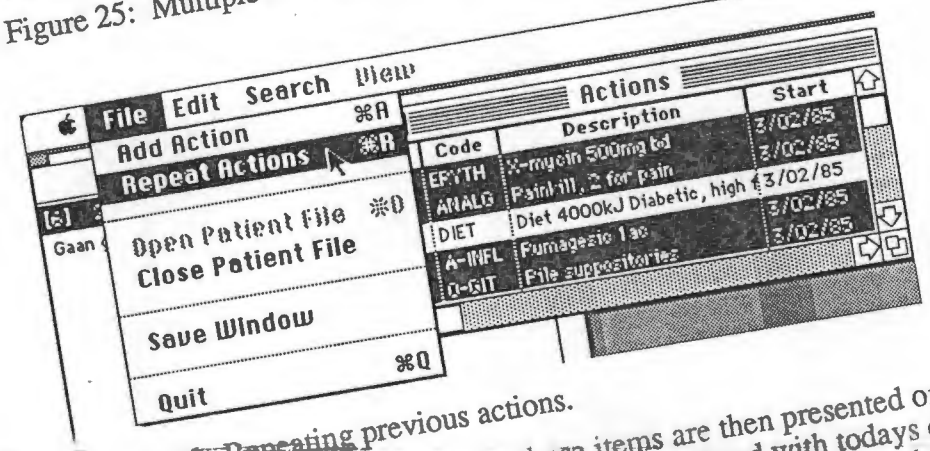


Figure 26: Repeating previous actions.

The "Action" dialogue boxes for those items are then presented one after another f completion. All of the details are already completed with todays date and the curr contact number. If necessary changed can be made to the items before clicking in "OK" button for completion. If the "Cancel" button is clicked that item is not repea

1.3.8 Adding a Referral to the Referral List.

The same series of actions is used as in adding an action to the "Action List":

a. Double click on the "Referral" icon (The icon fifth from left, depic pointing finger), this action will display the "Referral List" windc make it the active window.

b. Choose the "Add Referral" item from the "File" menu (Figure 27).

c. Complete the "Referral" dialogue box (Figure 28).

d. Click on the "OK" button in the "Referral" dialogue box.

We will be adding a referral to the laboratory for a glucose tolerance test t tient's record.

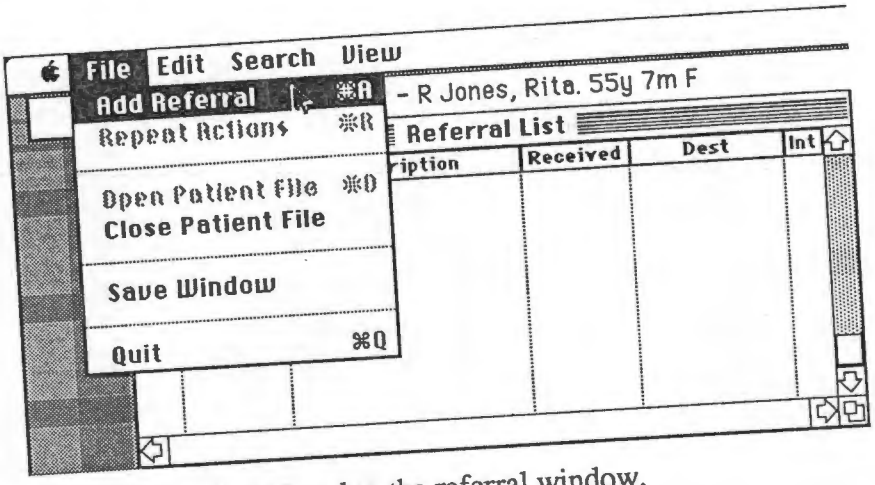


Figure 27: Add a referral to the referral window.

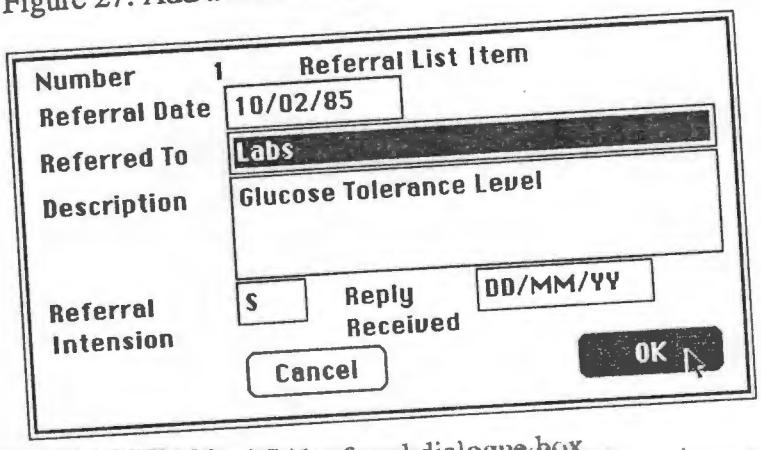


Figure 28: Completed referral dialogue box.

The "Referral date" field contains the date of the referral, this is set by default to the current date. It can be changed if necessary. The "Referred to" field contains a short description of the destination of the referral. The "Description" field is completed with a short description of the nature of the referral. There are three possible values for the "Referral intention" field: "O" for "Opinion", "C" for "Consultation", and "S" for "Special investigation". The "Reply received" field is normally completed only when the reply has been received. Figure 29 shows the window with the completed referral displayed. The result of a referral is normally documented in the progress notes.

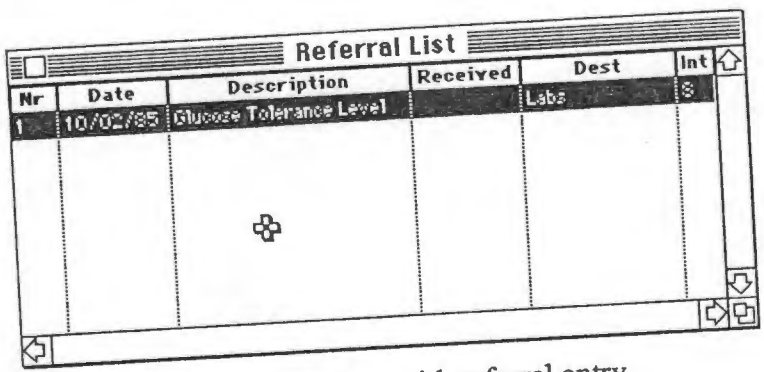


Figure 29: Referral window with referral entry.

1.3.9 Adding a flow sheet entry.

Adding a flow sheet entry follows the well known sequence, with slight modifications:

a. Double click on the "Flow Sheet" icon (The icon second from right, depicting a flow sheet), this action will display the "Flow Sheet" window and make it the active window. (Figure 30)

b. Choose the "Add Flow Sheet Entry" item from the "File" menu (Fig 31).

c. Enter the values directly on the flow sheet (Figure 34).

d. Press the "Tab" key to move from field to field.

We will create a flow sheet with space to record the date, blood pressure, pulse, weight, and random blood sugar. The sequence of actions differ slightly the first time entries are added to the flow sheet, because you are required to specify the columns in which you want to record the entries(Figures 32 & 33). You can recognize this state of affairs by a flow sheet devoid of columns (Figure 30).

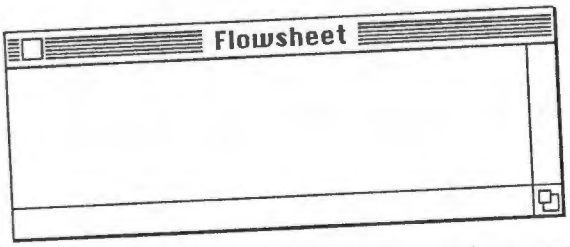


Figure 30: Flow Sheet window without any entries.

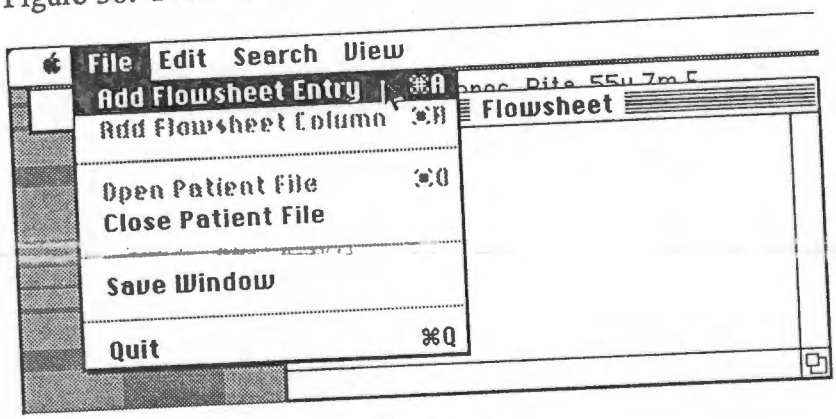


Figure 31: Adding a Flow Sheet entry.

In case of an empty flow sheet you will be presented with the following dialogue (Figure 32) to complete, in order to specify the column headings for the flow sheet.

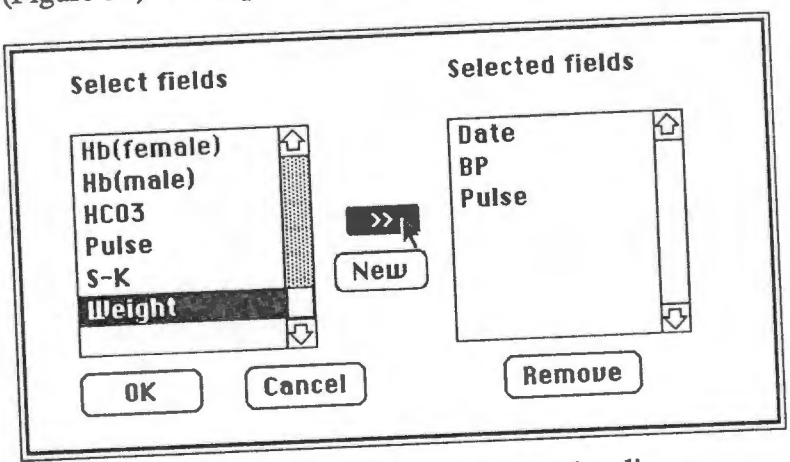


Figure 32: Specifying Flow Sheet column headings.

The window on the left lists all the available headings in alphabetical sequence. You select a headings you want and click on the ">>" button, which then transfers your selection to the right hand window. You repeat this process until all the headings that

you require have been transferred. Headings that have been transferred incorrectly can be removed by selecting them in the right hand window and clicking on the "Remove" button. If you require a heading that is not listed in the left hand window, click on the "New" button to create your own heading (Figure 33). When you have completed the heading selection process, click on the "OK" button.

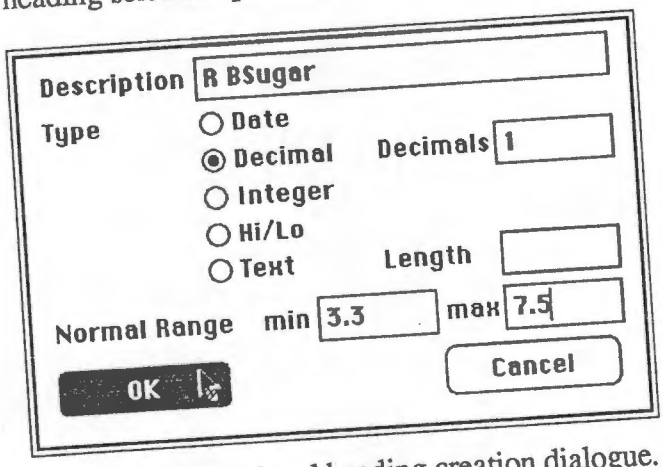


Figure 33: Completed heading creation dialogue.

To create a new heading you need to give it a name in the "Description" field. You must also specify what kind of data will be kept in these fields, by clicking in the circles opposite the appropriate data description.

a. Date. Choose this data type if you want to store dates.

b. Decimal. This data type allows you to store values that have numbers after the decimal point. You must specify the maximum number of numerals after the decimal point in the "Decimals" field.

c. Integer. If you want to store numbers that contain no numerals after the decimal point (whole numbers) then use this data type.

d. Hi/Lo. This data type is almost exclusively used for blood pressure values.

e. Text. Text can also be stored in flow sheets, but the maximum size of the text in characters must be specified in the "Length" field.

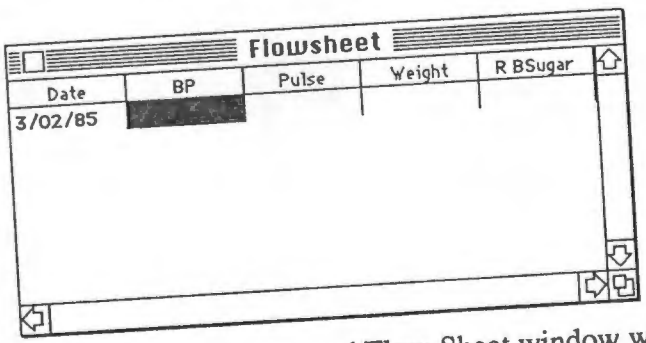


Figure 34: Newly created Flow Sheet window with headings.

A normal range for the flow sheet heading can also be added by typing the minimum and maximum values in the "Min" and "Max" fields.

When you have completed this process click on the "OK" button. You will then return to the heading selection dialogue. Here you can select and transfer your newly created heading to the right hand window.

At the end your flow sheet window should look like Figure 34.

The date has already been entered into the date column for you. The blood pressure

field is selected, ready for you to enter the value. Blood pressure readings are entered in the format "120/80", that is systolic value separated by a "/" from the diastolic value. As you have notice values are entered directly in the window (Figure 35), in contrast with the other windows that use a separate dialogue box.

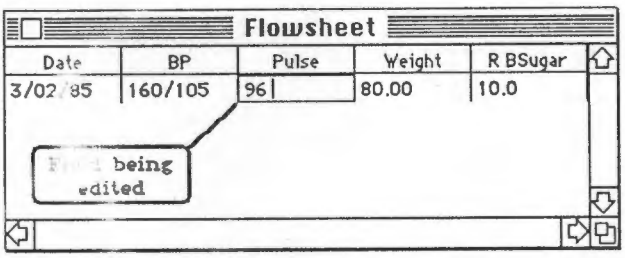


Figure 35: Field being edited in the Flow Sheet window.

1.3.10 Recording Problem Status Information

Recording the status of each problem at every consultation (contact) can be a useful way of recording a lot of information in a limited space. To record this make sure that the both the "Progress Notes" window and the "Problem List" window is being displayed by clicking on their respective icons. One of these windows should be the active window as well. Make certain that the contact for which you want to record the information is selected. It might also be that your contact (the contact documenting the current consultation with the patient) has not been added to the "Progress Notes" window yet, please do so now using the procedure as outlined in paragraph 3.5. Once you have made sure of the above, choose the "Show problem status" item from the "View" menu (Figure 36). A small window (Figure 37) will now be displayed. This window consists of a grid of blocks. The columns of this grid is numbered. These numbers corresponds to the numbers of the items in the "Problem List" window. Only active problems are listed. The rows of the grid are labeled with symbols indicating that possible states of a problem (Figure 37):

a. Improved. This is indicated by the "↑" symbol.

b. Stayed the same. This is indicated by the "→" symbol.

c. Worsened. This is indicated by the "↓" symbol.

d. Terminated. This is indicated by the "t" symbol.

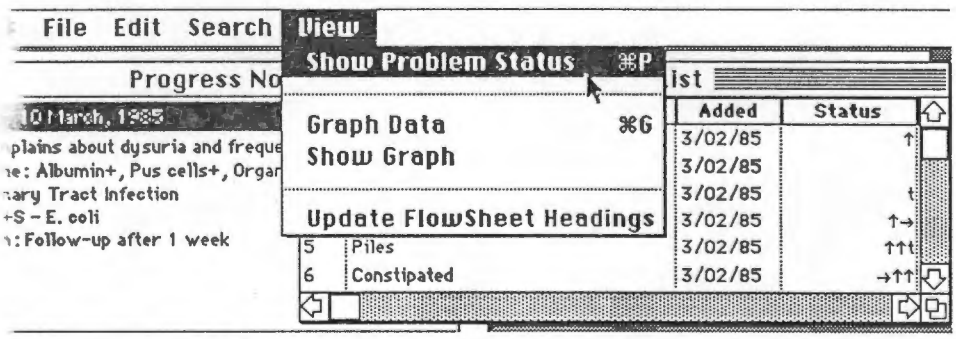


Figure 36: Show Problem Status.

Changes in the problem since the last visit of the patient are recorded as the problem state. When the problem has become better since the last visit, then the problem state is "improved".

To capture the status information of a problem, click in the rectangle formed by the intersection of the column bearing the number of the problem and the row with the appropriate status. In Figure 37 the arrow points to the block recording that problem 9 has worsened since the last visit of the patient. The status of a problem can be changed by simply clicking in the block belonging to the correct status. If you want to remove the status information of a problem, click on the number of the problem. If there are more than ten problems, the additional problems can be displayed by clicking on the "More" button. By clicking on the "OK" button the status information will be saved.

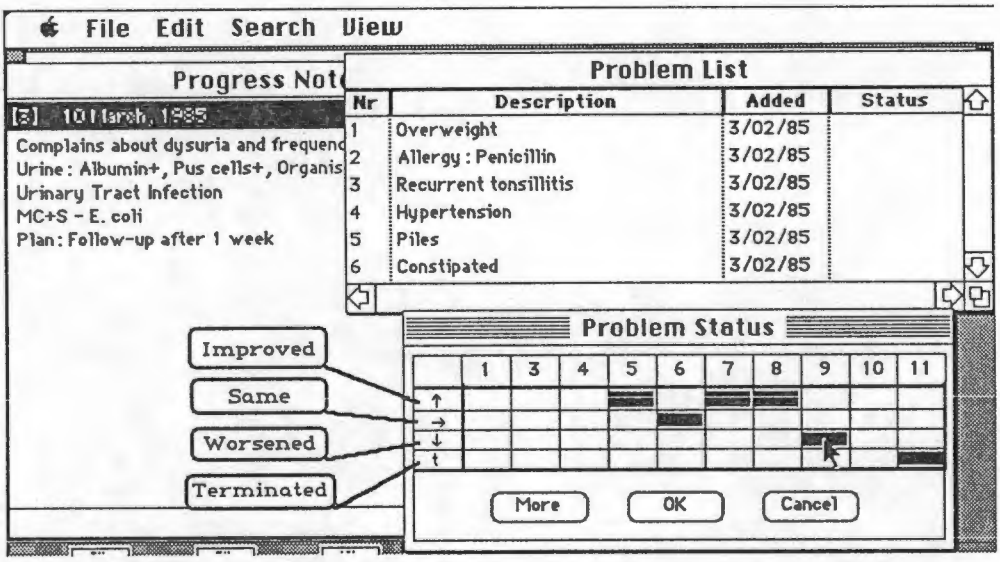


Figure 37: Problem Status window.

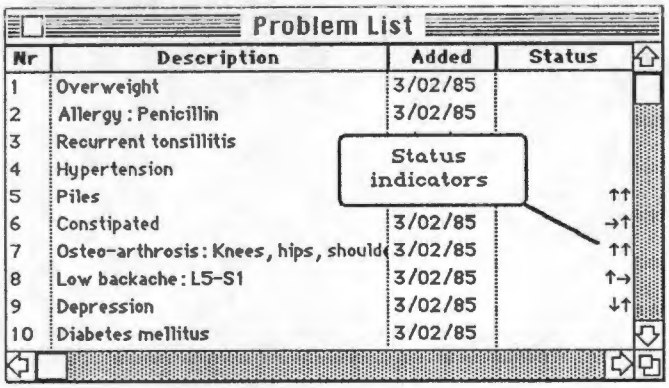


Figure 38: Problem List window showing status indicators.

The status information captured in the "Problem Status" window is displayed in the "Problem List" window (Figure 38) using the same status indicators explained above. For a particular problem the status information recorded at the last approximately ten contacts are displayed in the "Status" column (Figure 38). The indicators should be read from right to left, with the most recent ones on the right.

1.3.11 Searching for Information.

It is very important in a record system to obtain the information you need quickly and easily. This is one of the areas in which a computerized record systems really excel. IMIS is no exception to this and allows you to search for records satisfying various criteria. There are basically three ways in which you can do this:

a. Selection. When you select records only those records satisfying the search criteria are displayed in the window. You can then scroll through these records in the normal fashion. The "Select all" item from the "Search" menu will allow you to return to the state where all records are displayed in the window (Figure 45).

b. Find. The "Find" option will not change the number of records currently displayed in the window, but will highlight the first record satisfying the search criteria.

c. Link. One often wants to look at the information that was recorded at a particular consultation. The "Link" option allows you to do that.

1.3.11.1 Selecting Records.

In order to show you how this works we are going to select all the anti-inflammatory drugs our example patient, Mrs Jones, have received:

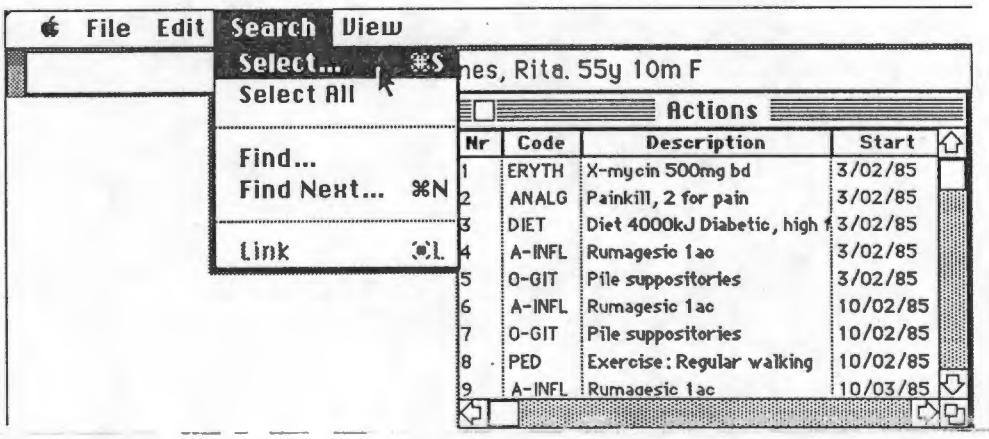


Figure 39: Selecting records.

a. Make the "Action List" window the active window by clicking twice on the "Action List" icon.

b. Choose "Select..." from the "Search" menu (Figure 39).

c. A dialogue box will now be displayed (Fig 40). Listed in this dialogue box are the various criteria according to which actions can be selected:

- On the description or part of the description of an action item.
- If the action was started between to specified dates.
- If the action was completed between to specified dates.
- On the action code or type.

You indicate which of the criteria you want to use in your search by clicking in the little box to the left of the criteria description.

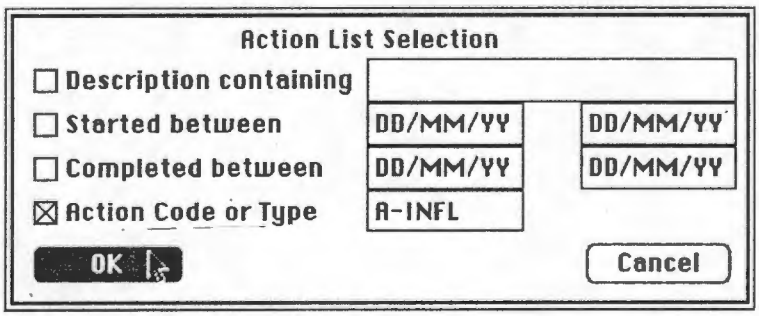


Figure 40: Selection dialogue box.

We are going to use the action code to do our search on, therefore we click on the little box next to the description "Action Code or Type" (Figure 40). In the field to the right of the description, we type the code we are interested in, namely, "A-INFL", which is the code for anti-inflammatory drugs.

d. Click on the "OK" button (Figure 40) and observe what happens to the "Action List" window (Figure 41).

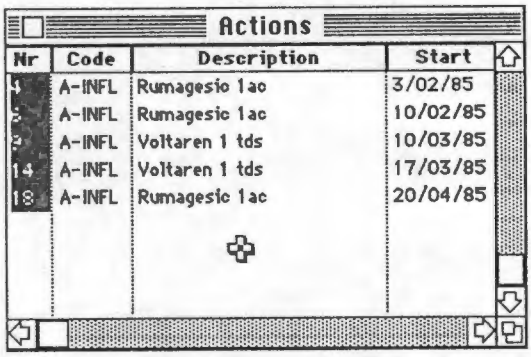


Figure 41: Action List window displaying selection.

Compare this "Action List" window to the one in Figure 39. The first thing to notice is that only anti-inflammatory drugs are now displayed. If you look at the action numbers in the left hand column you will notice that they are discontinuous, indicating that the records in between have not been selected. The column in which these numbers appear is also inverted (black), this enables you to notice at first sight that the records in a particular window is a subset of the records that could be displayed in that window.

e. It is also possible to use more than one criteria in your selection of records (Figure 42).

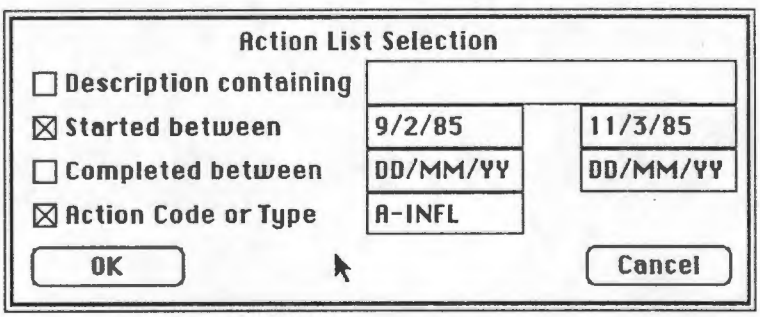


Figure 42: Using more than one selection criteria.

You do this by clicking in the small rectangle next to each criteria you want to use and entering values for them. In Figure 42 we have used both the "Started between" and the "Action code or type" criteria. The records that will be selected by these criteria will be: All anti-inflammatory drugs started between 9/2/85 and 11/3/85 (Figure 43).

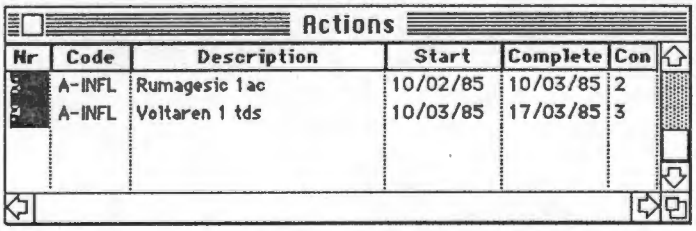


Figure 43: Result of selection on more than one criteria.

f. Similar selection can be done on most of the other windows, with the exception of the "Progress Notes" and "Baseline" windows. All these selections work in a similar fashion and Figure 44 shows the selection dialogue for selecting problems. Note the "Activity" criteria, the value of this criteria can either be "Active" or "Inactive", by clicking in either one of the round circles next to these values, a value can be assigned to the criteria. In this case (Figure 44) the value is "Inactive" and the window will therefore list all inactive problems.

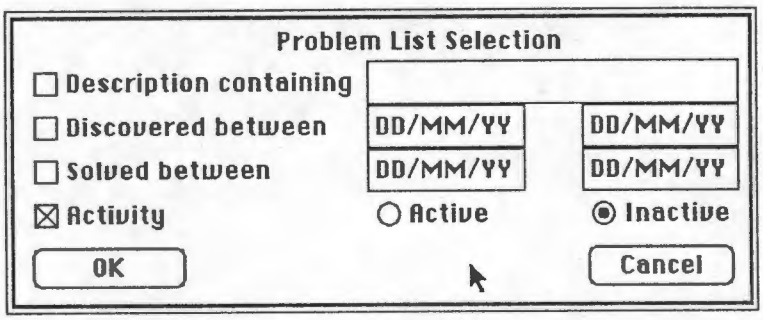


Figure 44: Problem List selection dialogue.

g. To return a window to the state where all records are shown, choose the "Select All" item from the "Search" menu (Figure 45).

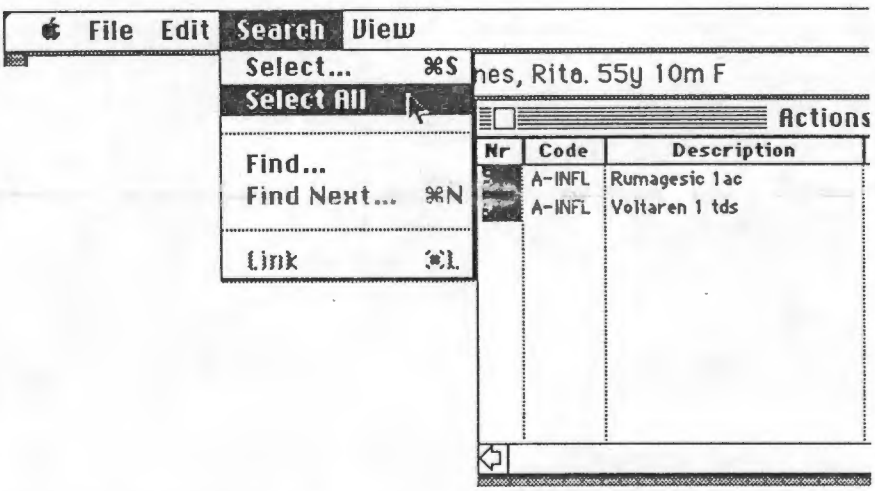


Figure 45: Displaying all the records in a window.

1.3.11.2 Finding Records.

Sometimes one just wants to locate the first occurrence of a record satisfying a particular set of criteria. The "Find" item under the "Search" menu is ideally suited for this task (Figure 46). In order to illustrate this function we shall locate the first time our example patient received "Voltaren":

a. Choose the "Find" item from the "Search" menu (Figure 46).

b. We complete the same dialogue that was shown in selecting records (Figure 47). Only this time we mark the criteria "Description containing" and type "Voltaren" as the value.

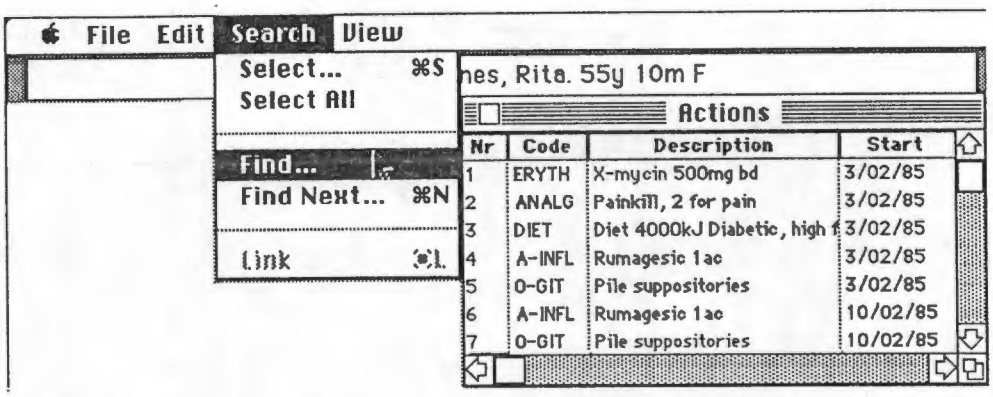


Figure 46: Finding a record.

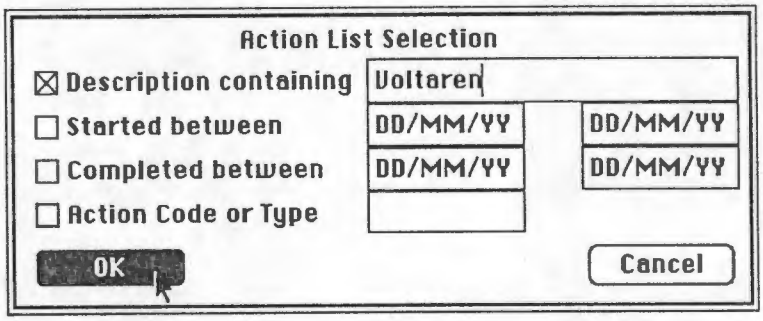


Figure 47: Finding a record by action description.

c. The "Action List" window is displayed with the first record containing the description "Voltaren" selected (Figure 48). Notice that it is not necessary to enter the exact contents of the description field, any word contained in the description will do. The window will scroll automatically to show the selected record.

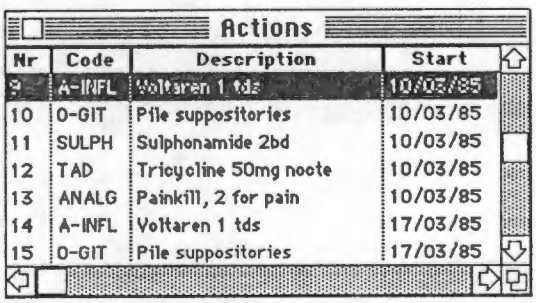


Figure 48: Action List window showing selected record.

d. By choosing the "Find next" item from the "Search" menu the next record containing "Voltaren" in its description field can be selected. (Figure 49).

e. This will result in record number 14 (Figure 48) being selected. The search dialogue (Figure 47) is not displayed again.

1.3.11.3 Link

The information that was recorded during a specific contact (consultation) can be obtained using the "Link" command. The "Link" command execute a series of selection operations on the "Problem List", "Action List" and "Referral List" windows that result in those windows displaying only those records captured at that particular contact. To use the "Link" command on our example patient, go through the following steps:

a. Make sure that the "Progress Notes" window is active by clicking twice on the "Progress Notes" icon.

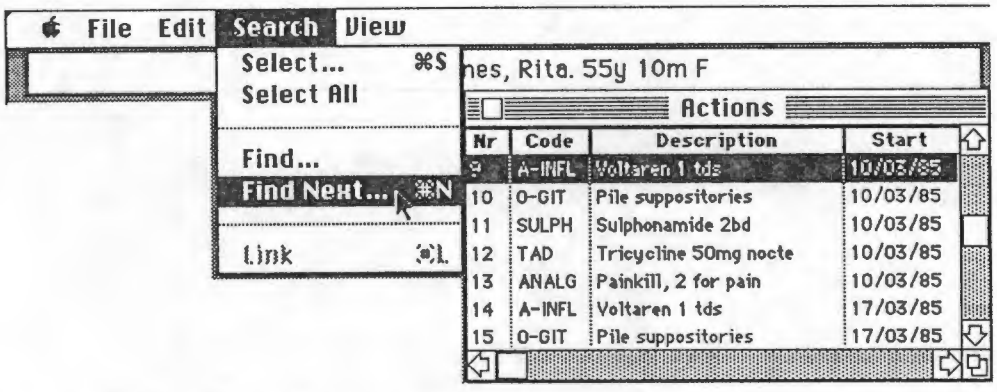


Figure 49: Finding the next record.

b. Select the contact of interest by clicking on the contact date. In this case we will choose contact number three.

c. Choose the "Link" item from the "Search" menu (Figure 50).

d. The display will now change to the one shown in Figure 51.

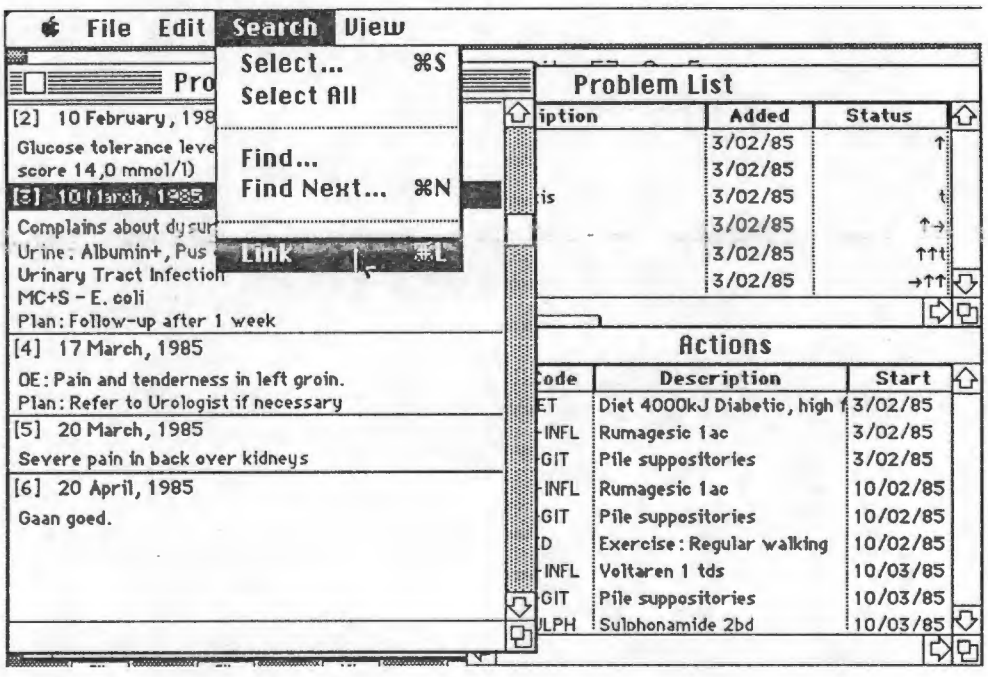


Figure 50: Using the Link command.

Notice that the "Problem List", "Action List", and "Referral List" windows now show only those records added during contact number three (Figure 51).

e. The windows can be individually changed to showing all records again by the "Select all" option (Figure 45).

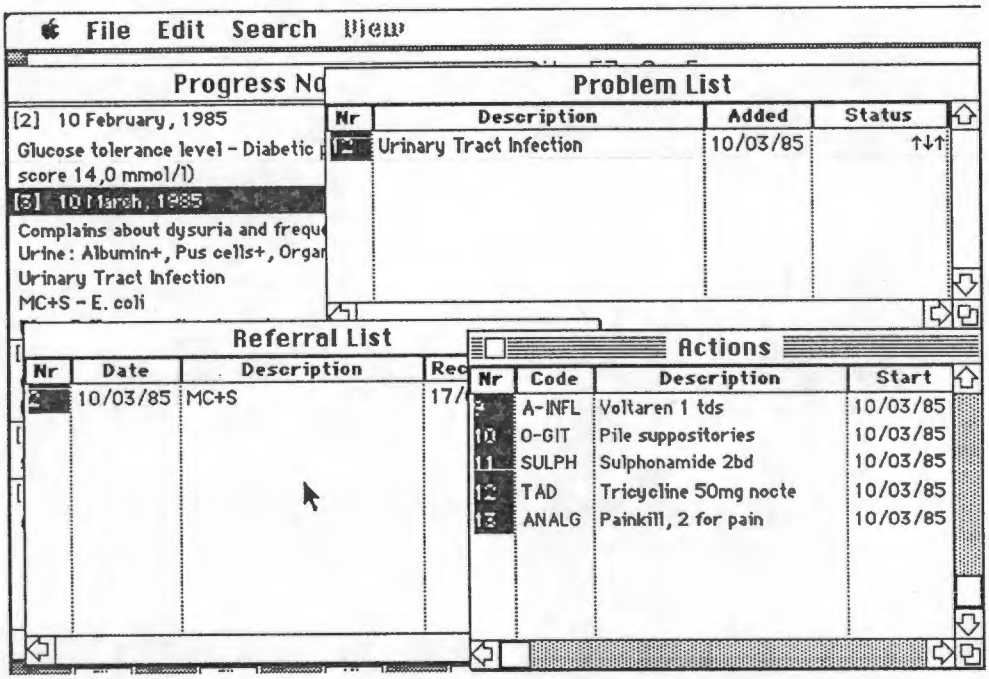


Figure 51: Display on completion of Link command.

1.3.12 Graphing

Graphs are often useful in showing trends in data. IMIS provides a facility to graph the values in a flow sheet column and the changes in a problem's status over time. An additional feature allows you to plot the duration of an action on the horizontal axis of the graph. ~~We shall be using a different example patient this time.~~

1.3.12.1 Graphing a Problem

A graph of a problem's status over time will show the relative improvement or worsening in the problem over time. Bear in mind that the changes are only relative and not absolute, therefore if the status of a problem returns to the base-line (zero) it doesn't necessarily mean that the problem is as worse as when it was initially discovered.

To graph a problem follow these steps:

a. Select the actions you want to display on the horizontal axis of the graph in the "Action List" window. This step is not essential and can be left out, the currently selected actions will be displayed in stead. Different actions will not be distinguished on the graph. The accumulated duration of all selected actions will be displayed as a black line on the horizontal axis of the graph (Figure 53).

b. Make sure that the "Problem List" window is the active window by clicking twice on the "Problem List" icon. Select the problem you want to graph.

c. Choose "Graph data" from the "View" menu. (Figure 52).

d. A graph will now be displayed (Figure 53). It will probably be necessary to click somewhere on the graph to bring it to the front of the rest of the windows.

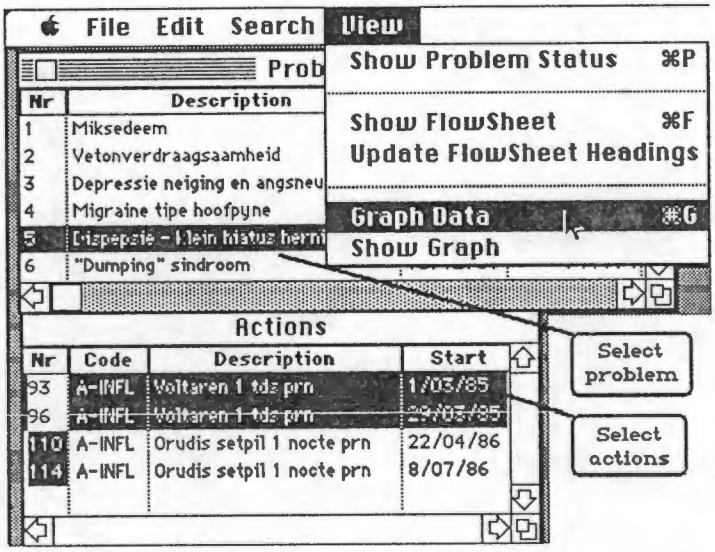


Figure 52: Graphing a Problem.

The black line above the date 17/03/85 shows the duration of the selected actions (Figure 53). As you can see from Figure 52 anti-inflammatory drugs have been selected, looking at the graph in Figure 53 one can see that Problem 5 (Dyspepsia) worsened during the duration of the anti-inflammatory treatment and improved on discontinuation.

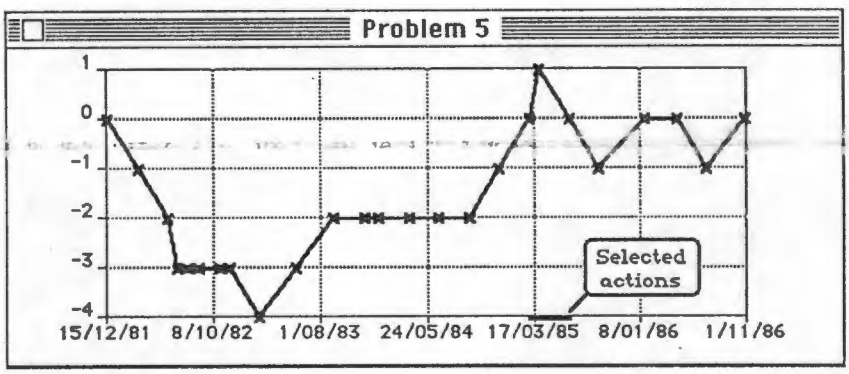


Figure 53: A graph of a Problem.

1.3.12.2 Graphing Flow sheet Data

The process of graphing flow sheet data is very similar to the graphing of problems. A difference is that normal ranges are shown on the graph when available. The process then is as follows:

a. Select the actions you want to display on the horizontal axis.

b. Make sure that the flow sheet window is active by clicking twice on the flow sheet icon.

c. Select the data in which you are interested. A partial column or a complete column can be selected, but the selection should not cross the boundary between columns. A quick way to select a complete column is to click on the column title.

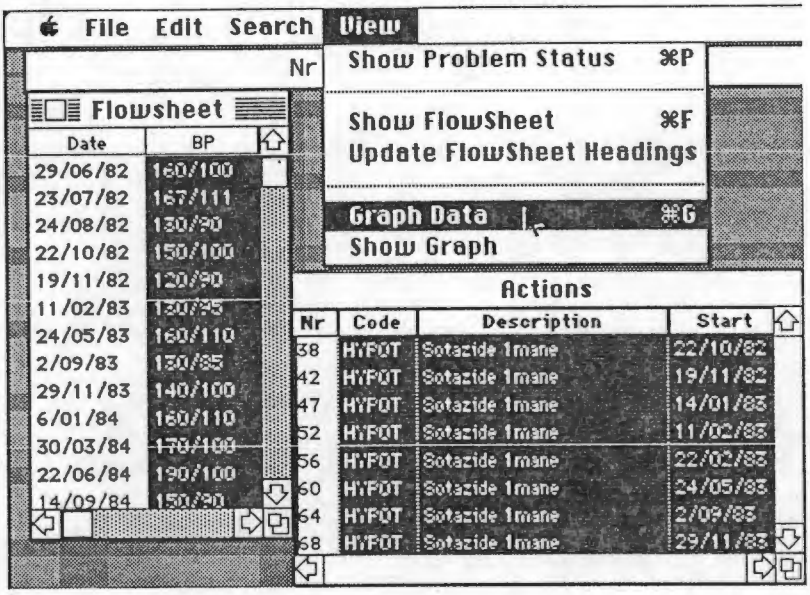


Figure 54: Graphing Flow Sheet data.

d. Choose the "Graph data" option from the "View" menu (Figure 54).

e. In our example we are graphing blood pressure values and the duration of "Sotazide" therapy (Figure 55).

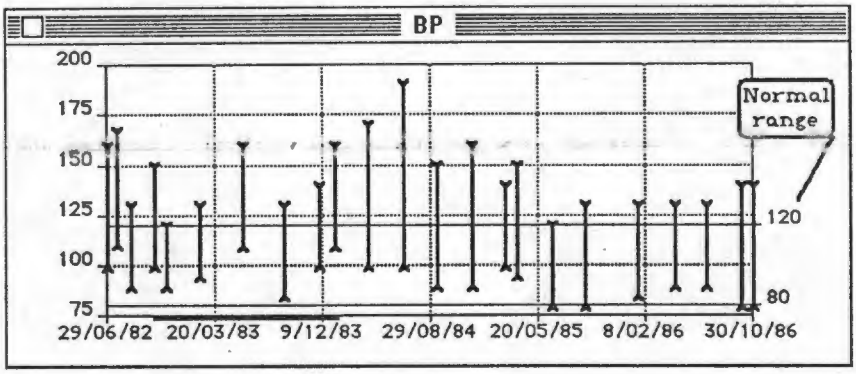


Figure 55: Blood pressure graph.

Section Two : Standard Techniques

2.1 Window Types

These standard techniques differ slightly between types of windows. The following types of windows are used in IMIS:

a. Tabular Windows. These windows show data in tables. Each column in the table represents a field. The name of the field is displayed at the top of the column. Each row in the table represents a record. Records are numbered sequentially in the leftmost column. When a subset of the available records are displayed this column is highlighted. The "Problem List", "Action List", "Referral List", and "Patient Identification" windows are all examples of tabular windows.

b. Flow sheet Window. This window is a special case of the tabular windows. It differs primarily in that individual fields can be selected and updated. More than one field can be selected by dragging across the fields while the mouse button is kept depressed. A complete column can be selected by clicking on the title of the column.

c. "Progress Notes" Window. Records can consist of more than one line. An individual record or contact can be selected by clicking anywhere on the record.

d. Special Windows. This include the "Status" and "Baseline" windows. Components in these windows are activated by clicking in the appropriate places. Scrolling is not implemented in these windows.

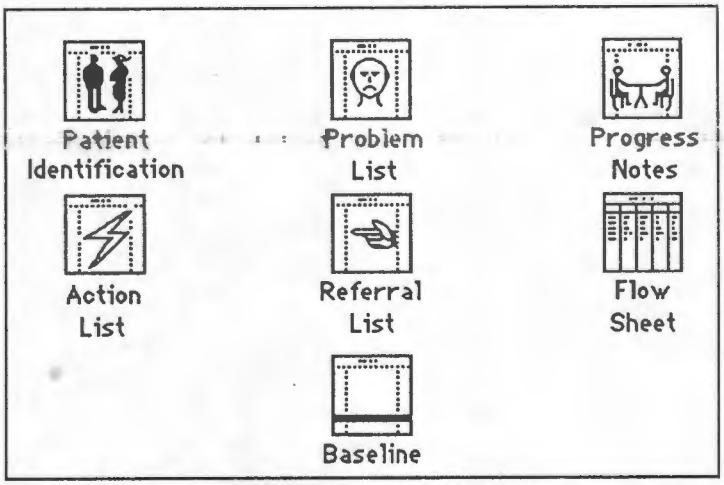


Figure 56: Window Icons.

e. Plain Windows. Plain windows include the name and graph windows. Actions cannot be performed on their contents.

2.2 Manipulating Windows

Windows are displayed by clicking on their corresponding icon. This is true for all windows except for the "Status" and plain windows. The "Patient Name" window is always visible. The "Status" and graph windows are displayed as a result of menu choices. The icons are shown in Figure 56.

To make a window the active or frontmost window click twice on the window's icon.

2.3 Manipulating Records

Records consists of fields and is representative of an activity that happened at a particular time. For example a "Action List" record (Figure 57) might describe one medication given to a patient. This medication has a number - "1", a code - "ERYTH", a description - "X-mycin 500mg bd", a date on which it was started - "3/02/85", a date on which it was completed - "10/02/85", and a contact during which it was given - "1". A record such as this one is always manipulated as a whole.

Nr	Code	Description	Start	Complete	Con
1	ERYTH	X-mycin 500mg bd	3/02/85	10/02/85	1

Figure 57: One Action List record.

A number of operations can be done on records:

a. Selection. A record is selected by clicking on the record. To indicate that the record had been selected it will be inverted (Figure 58).

Nr	Code	Description	Start	Complete	Con
1	ERYTH	X-mycin 500mg bd	3/02/85	10/02/85	1

Figure 58: Inverted Action List record.

b. Modification. The values of the fields in a record can be changed by clicking on a record that is currently selected. This will cause a dialogue box to be displayed in which you can change any of the field values (Figure 59). Notice that this is exactly the same dialogue as the one used to add a record (Figure 24).

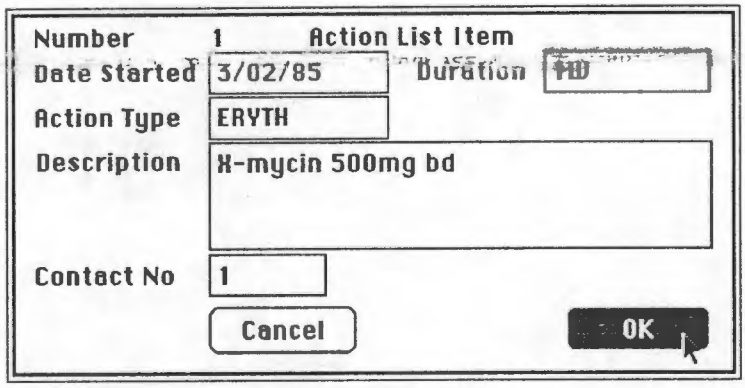


Figure 59: Modifying an Action List record.

c. Deletion. Some tabular windows will allow you to delete a record by first selecting the record and then choosing the "Clear" command from the "Edit" menu.

c. Duplication. Some tabular windows will allow you to duplicate a record by first selecting the record and then choosing the "Duplicate" command from the "Edit" menu.

2.4 Quitting the Application

You may leave the application at any time by choosing the "Quit" command from the "File" menu. If there are unsaved information you will be prompted to save it.

PROBLEMS

1 Individual Problems Grouped by Type[1]

1.1 Lexical Problems

1. Clicked by accident in open area of window (1)
2. Clicked twice on selected record by mistake (2)
3. Difficulty in doing multiple selections. (3)
4. Difficulty with click to make window active. (4)
5. Difficulty with mechanism to show menu. (5)
6. Difficulty with scrolling. (6)
7. Spelling causes search difficulties. (7)

1.2 Syntactic Problems

1. Clicked on icon even though window already open. (8)
2. Clicked only once on icon - window not active. (9)
3. Difficulty in "unselecting" a record. (10)
4. Difficulty in canceling dialogue. (12)
5. Difficulty in making window active. (11)
6. Difficulty in selecting correct icon. (13)
7. Difficulty to edit text in a field. (14)
8. Difficulty to remove wrong status indicator. (15)
9. Difficulty to scroll status window. (16)
10. Difficulty to tab from field to field. (17)
11. Difficulty with dialogue fields. (18)
12. Difficulty with sequence of "Graph Data" vs "Show Graph". (19)
13. Difficulty with termination. (20)
14. Gave command before selection of data. (21)
15. Gave menu command for a window not currently active. (22)
16. Incorrect action - press enter instead of menu command to repeat. (23)
17. Left out medication name. (24)
18. Premature termination of problem capture. (25)
19. Unnecessary repetition of "Select All" function. (26)
20. Unsure whether patient file is already open. (27)
21. Used add option instead of repeat option. (28)

1.3 Semantic Problems

1. Difficulty in changing context from previous window to current window. (29)
2. Difficulty in interpretation of arrow symbols. (30)
3. Difficulty in interpretation of conventions. (31)
4. Difficulty in interpretation of graph. (35)
5. Difficulty in recognizing status change. (32)
6. Difficulty to classify "Gastroscopy" as referral. (33)
7. Difficulty with application of search function. (34)
8. Difficulty with search criteria. (36)
9. Difficulty with subset of records. (37)
10. Inappropriate menu actions. (38)
11. Inappropriate use of "Link" command. (39)

---

1 The number in brackets refer to the code number for the problem used in Chapter Five.

12. Inappropriate use of "Search" command. (40)
13. Incorrect interpretation of record. (41)
14. Incorrect interpretation of record sequence. (44)
15. Unsure whether problem is active. (42)
16. Used wrong action code. (43)

1.4 Conceptual problems.

1. Search function not available for all windows. (45)
2. Unnecessary scroll of window to add entries. (46)
3. Unsure about method. (47)
4. Used a method that complicated task. (48)

1.5 Difficulty in finding

1. Associated a wrong number with the problem. (49)
2. Difficulty in finding item in table. (50)
3. Difficulty in finding medication. (51)
4. Difficulty in finding medication list. (52)
5. Difficulty in finding problem not yet on problem list. (53)
6. Difficulty in orientation within list. (54)
7. Difficulty to find problem status menu option. (55)
8. Difficulty with invisible fields in window. (56)
9. Difficulty with readability of record. (57)
10. Difficulty with record format. (58)
11. Doesn't give attention to error message. (59)
12. Doesn't give attention to information on screen. (60)
13. Doesn't notice that entry has already been added. (61)
14. Doesn't see additional entries in record. (62)
15. Graph not visible after drawing. (63)
16. Icon obscured by window. (64)
17. Identified wrong date. (65)
18. Incomplete Record. (66)
19. Looked at wrong component of record. (67)
20. Looked in wrong column of window. (68)
21. Reading from wrong medication list. (69)
22. Selected wrong contact. (70)
23. Unclear information on record. (71)
24. Unnecessary use of search function for data already on screen. (72)
25. Unsure about place on record. (73)

2 Problems per Task

2.1 Retrieval

2.1.1 Manual Retrieval

2.1.1.1 Open File

2.1.1.2 Which problem added on date

1. Difficulty with readability of record
2. Incomplete record

2.1.1.3 When was problem added

1. Incomplete record
2. Incorrect interpretation of record

2.1.1.4 When was problem terminated

1. Difficulty in finding item in table
2. Difficulty with record format
3. Incomplete record
4. Incorrect interpretation of record

2.1.1.5 What was the problem status on date

2.1.1.6 What was the problem status last time problem was addressed

1. Difficulty with readability of record

2.1.1.7 Read progress notes belonging to date

2.1.1.8 Find statement in progress notes

1. Difficulty with readability of record
2. Looked at wrong component of record

2.1.1.9 Which medications were given on date

1. Difficulty in interpretation of conventions
2. Difficulty with readability of record
3. Reading from wrong medication list

2.1.1.10 When did patient last receive a particular medication

1. Difficulty in interpretation of conventions
2. Difficulty with readability of record
3. Doesn't see additional entries in record
4. Unclear information on record

2.1.1.11 When was a specific referral last done

1. Difficulty in interpretation of conventions

2.1.1.12 Has result of referral been received

1. Incorrect interpretation of record

2.1.1.13 What was the value on date (Flow Sheet)

2.1.1.14 When last was an entry a specific value

2.1.1.15 What happened to a problem while receiving a medication

1. Difficulty in finding medication
2. Difficulty in interpretation of conventions
3. Difficulty in recognizing status change

2.1.1.16 What was the change in problem over time

2.1.1.17 When and how was the dosage of medication changed

1. Difficulty in interpretation of conventions
2. Difficulty with record format
3. Doesn't see additional entries in record
4. Unclear information on record

2.1.1.18 How many referrals of a certain kind were there

1. Difficulty with record format
2. Unclear information on record

2.1.2 Computer Retrieval

2.1.2.1 Open File

1. Clicked twice on selected record by mistake
2. Difficulty with mechanism to show menu

2.1.2.2 Which problem added on date

1. Difficulty in selecting correct icon
2. Inappropriate use of "Search" command
3. Looked at wrong component of record

2.1.2.3 When was problem added

1. Inappropriate use of "Search" command
2. Unsure about method

2.1.2.4 When was problem terminated

1. Difficulty with invisible fields in window
2. Looked in wrong column of window
3. Unsure about method

2.1.2.5 What was the problem status on date

1. Associated a wrong number with the problem
2. Clicked by accident in open area of window
3. Clicked twice on selected record by mistake
4. Difficulty in canceling dialogue
5. Difficulty in interpretation of arrow symbols
6. Difficulty in making window active
7. Difficulty with scrolling
8. Difficulty with search criteria
9. Doesn't give attention to error message
10. Inappropriate use of "Search" command
11. Selected wrong contact
12. Unsure about method

2.1.2.6 What was the problem status last time problem was addressed

1. Clicked twice on selected record by mistake
2. Difficulty with subset of records
3. Inappropriate use of "Search" command
4. Unsure about method

2.1.2.7 Read progress notes belonging to date

1. Identified wrong date

2.1.2.8 Find statement in progress notes

1. Clicked on icon even though window already open
2. Difficulty with scrolling
3. Inappropriate use of "Search" command
4. Looked at wrong component of record
5. Unsure about method

2.1.2.9 Which medications were given on date

1. Clicked twice on selected record by mistake
2. Difficulty in finding item in table
3. Difficulty with scrolling
4. Difficulty with subset of records
5. Gave menu command for a window not currently active
6. Looked in wrong column of window

2.1.2.10 When did patient last receive a particular medication

1. Clicked by accident in open area of window
2. Difficulty with search criteria
3. Spelling causes search difficulties
4. Unsure about method
5. Used a method that complicated task

2.1.2.11 When was a specific referral last done

1. Difficulty in finding item in table
2. Difficulty in orientation within list
3. Difficulty in selecting correct icon
4. Gave menu command for a window not currently active
5. Incorrect interpretation of record sequence
6. Looked at wrong component of record
7. Spelling causes search difficulties
8. Unsure about method

2.1.2.12 Has result of referral been received

1. Clicked on icon even though window already open
2. Difficulty to edit text in a field
3. Difficulty with dialogue fields
4. Doesn't give attention to information on screen
5. Inappropriate use of "Search" command
6. Unsure about method

2.1.2.13 What was the value on date (Flow Sheet)

2.1.2.14 When last was an entry a specific value

1. Difficulty with scrolling
2. Gave command before selection of data
3. Graph not visible after drawing
4. Search function not available for all windows

2.1.2.15 What happened to a problem while receiving a medication

1. Clicked by accident in open area of window
2. Difficulty in doing multiple selections
3. Difficulty in finding item in table
4. Difficulty in interpretation of graph
5. Difficulty in selecting correct icon
6. Difficulty with mechanism to show menu
7. Difficulty with sequence of "Graph Data" vs "Show Graph"
8. Gave menu command for a window not currently active
9. Graph not visible after drawing
10. Inappropriate use of "Link" command
11. Inappropriate use of "Search" command
12. Unnecessary use of search function for data already on screen
13. Unsure about method

2.1.2.16 What was the change in problem over time

1. Difficulty in finding item in table
2. Difficulty in interpretation of graph
3. Difficulty with sequence of "Graph Data" vs "Show Graph"

2.1.2.17 When and how was the dosage of medication changed

1. Difficulty in "unselecting" a record
2. Difficulty with application of search function
3. Difficulty with search criteria
4. Unnecessary repetition of "Select All" function
5. Unsure about method

2.1.2.18 How many referrals of a certain kind were there

1. Difficulty in finding item in table
2. Difficulty in selecting correct icon
3. Difficulty to classify "Gastroscopy" as referral
4. Unnecessary repetition of "Select All" function

2.2 Capture

2.2.1 Manual Capture

2.2.1.1 Open File

2.2.1.2 Add Contact

1. Unsure about place on record

2.2.1.3 Document Problem Status

1. Difficulty in finding problem not yet on problem list
2. Difficulty with readability of record

2.2.1.4 Add Flow Sheet entries

2.2.1.5 Do Progress notes

2.2.1.6 Add problem

2.2.1.7 Document referral

2.2.1.8 Repeat Actions

1. Difficulty in finding medication list
2. Difficulty with readability of record

2.2.1.9 Add Actions

2.2.2 Computer Capture

2.2.2.1 Open File

1. Difficulty with mechanism to show menu
2. Difficulty with scrolling
3. Unsure about method

2.2.2.2 Add Contact

1. Clicked on icon even though window already open
2. Difficulty in selecting correct icon
3. Difficulty with scrolling
4. Difficulty with termination
5. Unsure about method

2.2.2.3 Document Problem Status

1. Difficulty in finding item in table
2. Difficulty in interpretation of arrow symbols
3. Difficulty in selecting correct icon
4. Difficulty to find problem status menu option
5. Difficulty to remove wrong status indicator
6. Difficulty to scroll status window
7. Difficulty with click to make window active
8. Difficulty with scrolling
9. Inappropriate menu actions
10. Unsure about method

2.2.2.4 Add Flow Sheet entries

1. Difficulty in selecting correct icon
2. Difficulty to tab from field to field
3. Difficulty with termination
4. Doesn't notice that entry has already been added
5. Unnecessary scroll of window to add entries
6. Unsure about method

2.2.2.5 Do Progress notes

1. Clicked on icon even though window already open
2. Difficulty in changing context from previous window to current window
3. Difficulty with termination
4. Unsure about method
5. Unsure whether patient file is already open

2.2.2.6 Add problem

1. Difficulty in changing context from previous window to current window
2. Difficulty with dialogue fields

3. Premature termination of problem capture
4. Unsure about method
5. Unsure whether problem is active

2.2.2.7 Document referral

1. Difficulty with dialogue fields
2. Difficulty with scrolling
3. Icon obscured by window
4. Unsure about method

2.2.2.8 Repeat Actions

1. Clicked only once on icon - window not active
2. Clicked twice on selected record by mistake
3. Difficulty in doing multiple selections
4. Difficulty to edit text in a field
5. Gave command before selection of data
6. Incorrect action - press enter instead of menu command to repeat
7. Used add option instead of repeat option

2.2.2.9 Add Actions

1. Difficulty in selecting correct icon
2. Difficulty with dialogue fields
3. Difficulty with scrolling
4. Difficulty with termination
5. Inappropriate menu actions
6. Left out medication name
7. Used incorrect action code

SUGGESTED IMPROVEMENTS TO THE SYSTEMS

No	Error No[1]	Error Description	C [2]	M/C [3]	n [4]	Cause	Action / System Improvement	Pr [5]
1	1	Clicked by accident in open area of window	Lex	C	5	Accidental action	Use double click on open area to add record	H
2	2	Clicked twice on selected record by mistake	Lex	C	9	Accidental action	Use double click to open record for action	H
3	3	Difficulty in doing multiple selections	Lex	C	5	Contrary to user guide-lines	Implement standard selection mechanisms	H
4	10	Difficulty in "unselecting" a record	Syn	C	1	Contrary to user guide-lines	Use single click to unselect record	L
5	4	Difficulty with click to make window active	Lex	C	4	Difficulty with concept of "active" window	Training, mention in manual. First click should have no action to prevent accidental changes	M
6	11	Difficulty in making window active	Syn	C	2	Concept of active window	Training	L
7	22	Gave menu command for a window not currently active	Syn	C	8	Object - verb sequence, active window concept	Training	M
8	21	Gave command before selection of data	Syn	C	5	Object - verb sequence	Stress this connection in training	M
9	5	Difficulty with mechanism to show menu	Lex	C	3	Manual dexterity	Training in to use computer system	M
10	6	Difficulty with scrolling	Lex	C	20	Manual dexterity	Training in to use computer system	H
11	16	Difficulty to scroll status window	Syn	C	4	Scrolling status window different from other windows	Consider changing scrolling mechanism	M
12	46	Unnecessary scroll of window to add entries	Con	C	8	Interference from paper record - must see place first before you can add information	Automatic scroll to end of window on opening	M
13	7	Spelling causes search difficulties	Lex	C	3	Spelling	Coded selection, "canned" descriptions	L
14	8	Clicked on icon even though window already open	Syn	C	6	Insufficient visual feedback	Gray icon when window is open	M
15	9	Clicked only once on icon - window not active	Syn	C	1	Intention to use window, additional action not planned for	Make window active when user clicks on icon	L
16	13	Difficulty in selecting correct icon	Syn	C	10	Mnemonics	Improve design of icons	H
17	12	Difficulty in canceling dialogue	Syn	C	1	Unfamiliarity	Improve training in dialogue techniques	L
18	14	Difficulty to edit text in a field	Syn	C	6	Manual dexterity	Training in editing techniques	M
19	17	Difficulty to tab from field to field	Syn	C	1	Limited knowledge of dialogue use	Improve training in dialogue techniques	L
20	18	Difficulty with dialogue fields	Syn	C	9	Limited knowledge of dialogue use	Improve training in dialogue techniques	H
21	15	Difficulty to remove wrong status indicator	Syn	C	1	Unfamiliarity	Training	L
22	19	Difficulty with sequence of "Graph Data" vs "Show Graph"	Syn	C	3	One intention but two separate actions	Function unnecessarily complicated, combine	L
23	63	Graph not visible after drawing	Fin	C	4	Graph obscured by other windows	Make graph frontmost window	L
24	20	Difficulty with termination	Syn	C	16	Counter intuitive design of function	Redesign method of adding a contact	H
25	23	Incorrect action - press enter instead of menu command to repeat	Syn	C	3	Unfamiliarity	Training	L
26	28	Used add option instead of repeat option	Syn	C	2	?Proximity on menu	?Redesign action recording	L
27	24	Left out medication name	Syn	C	2	Insufficient error checking	Add error checking	L
28	25	Premature termination of problem capture	Syn	C	1	Insufficient error checking	Add error checking	L
29	61	Doesn't notice that entry has already been added	Fin	C	2	Insufficient error checking	Add error checking	L
30	27	Unsure whether patient file is already open	Syn	C	1	Unfamiliarity, ?Insufficient feedback	"Float" name window	L
31	29	Difficulty in changing context from previous window to current window	Sem	C	2	Difficulty in associating function with particular window	Training	L
32	30	Difficulty in interpretation of arrow symbols	Sem	C	6	Confusion in meaning of symbols	Replace symbols with words	M
33	35	Difficulty in interpretation of graph	Sem	C	10	Confusion in meaning of symbols	Replace symbols with words	H
34	33	Difficulty to classify "Gastroscopy" as referral	Sem	C	1	Unclear definition of "referral"	Improve manual	L
35	34	Difficulty with application of search function	Sem	C	2	Unfamiliarity	Training or simplify function	L
36	36	Difficulty with search criteria	Sem	C	7	Conceptually difficult, unavailable in manual system	Training	M
37	40	Inappropriate use of "Search" command	Sem	C	13	Search command not consistently available	Add to flow sheet and notes	H
38	45	Search function not available for all windows	Con	C	1	Search command not consistently available	Add to flow sheet and notes	L
39	72	Unnecessary use of search function for data already on screen	Fin	C	1	Unfamiliarity, ?Stress	Training	L
40	37	Difficulty with subset of records	Sem	C	9	Difficulty with concept of selective display	Training	L
41	26	Unnecessary repetition of "Select All" function	Syn	C	2	Difficulty with concept of selective display	Training	M
42	38	Inappropriate menu actions	Sem	C	3	Searching for correct command, unfamiliarity	Training	L
43	39	Inappropriate use of "Link" command	Sem	C	1	Unfamiliarity	Training	L
44	43	Used wrong action code	Sem	C	1	? Unclear description of code, unfamiliarity	Training, error checking	L

No	Error No	Error Description	C	M/C	n	Cause	Action / System Improvement	Pr
45	47	Unsure about method	Con	C	50	Unfamiliarity	Training	H
46	48	Used a method that complicated task	Con	C	1	Unfamiliarity	Training	L
47	49	Associated a wrong number with the problem	Fin	C	2	Information spread over two windows	Add problem description to status display, or separate status display associated with problem as opposed to with contact	L
48	55	Difficulty to find problem status menu option	Fin	C	5	Unfamiliarity, placement of menu option	Redesign of status capture	M
49	44	Incorrect interpretation of record sequence	Sem	C	1	Unfamiliarity	Training	L
50	54	Difficulty in orientation within list	Fin	C	1	Unfamiliarity	Training	L
51	59	Doesn't give attention to error message	Fin	C	4	?Stress, interference with other computer system?		L
52	60	Doesn't give attention to information on screen	Fin	C	1	?Stress, interference with other computer system?		L
53	65	Identified wrong date	Fin	C	1	?	?	L
54	68	Looked in wrong column of window	Fin	C	4	Unfamiliarity, Placement of columns?	Training	L
55	70	Selected wrong contact	Fin	C	1	Cumbersome method of looking at previous status of a problem	Add facility	L
56	42	Unsure whether problem is active	Sem	C	1	Definition of "active"	Training, manual	L
57	56	Difficulty with invisible fields in window	Fin	C	6	Information not immediately visible	Larger display screen	M
58	64	Icon obscured by window	Fin	C	1	Crowded display	Larger display screen	L
59	50	Difficulty in finding item in table	Fin	MC	12	?Stress, ?letters too small, handwriting	Larger display with bigger letters	H
60	67	Looked at wrong component of record	Fin	MC	10	Unfamiliarity, format of record	Training	M
61	53	Difficulty in finding problem not yet on problem list	Fin	M	2	Unfamiliarity with convention, a problem can be in one of two places	Place all problems immediately on problem list	L
62	31	Difficulty in interpretation of conventions	Sem	M	14	Individual variation in conventions, familiarity	Training	H
63	32	Difficulty in recognizing status change	Sem	M	6	Cluttered format of manual record	Tabulate status change	M
64	41	Incorrect interpretation of record	Sem	M	5	Individual variation in conventions and writing style, implied relationship		M
65	51	Difficulty in finding medication	Fin	M	1	Method of recording medication - confusion with termination	?Separate medication list in same fashion as problem list	L
66	52	Difficulty in finding medication list	Fin	M	1	Method of recording medication	Separate medication list in same fashion as problem list	L
67	69	Reading from wrong medication list	Fin	M	4	Method of recording medication	Separate medication list in same fashion as problem list	M
68	71	Unclear information on record	Fin	M	7	Method of recording medication termination	Separate medication list in same fashion as problem list	H
69	57	Difficulty with readability of record	Fin	M	15	Handwriting		H
70	58	Difficulty with record format	Fin	M	11	Individual variation in conventions, familiarity, training, medication list and termination of medications		H
71	62	Doesn't see additional entries in record	Fin	M	3	Handwriting, cluttered format		L
72	66	Incomplete Record	Fin	M	10	No automatic error checking possible in manual record, no automatic entries, e.g. entering of today's date	Computerize	H
73	73	Unsure about place on record	Fin	M	2	Unfamiliarity with conventions	Training	2

Table C.1 System Improvements derived from an analysis of problems

No	Task No[6]	Task Description	C [7]	M/C	Cause	Action / System Improvement	Pr
1	5	What was problem status on date	Ret	C	Function too complex	Redesign problem status enquiry	H
2	15	What happened to problem while receiving medications	Ret	C	Unfamiliarity	Training	H
3	8	Find statement in progress notes	Ret	C	Search command not consistently available	Add search function to progress notes window	H
4	9	Which medications given on date	Ret	C	Variety of problems (See App B)	Training	M
5	10	When last was a specific medication given	Ret	C	Difficulty with complexity of search function	Training, simpler search function	M
6	11	When last was a specific referral done	Ret	C	Variety of problems (See App B)	Training	M
7	3	Document problem status	Cap	C	Complexity of task, especially switching between windows	Simplify function	H
8	4	Add flow sheet entries	Cap	C	Last entry on flow sheet not visible, termination problems	Scroll window automatically to last entry	H
9	8	Repeat actions	Cap	C	Complexity, selection difficulties	Simplify and implement standard selection techniques	H
10	5	Do progress notes	Cap	C	Termination problems	Redesign function	H
11	2	Add contact	Cap	C	See above	See above	H
12	4	When was problem terminated	Ret	M	Incomplete information on record		H
13	18	ow many of a certain referral were there	Ret	M	Information lost between other written information	Separate referral list	H

Table C.2 System Improvements derived from an analysis of task performance

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1 Error number as used in Appendix B.
2 Error clasification; Lex = Lexical, Syn = Syntactic, Sem = Semantic, Con = Conceptual, Fin = Finding
3 Manual or Computer system
4 Number of this problem experienced
5 Priority of change to system; H = High, M = Medium, L = Low
6 Task number in task group
7 Task clasification; Ret = Retrieval, Cap = Capture

EXAMPLES OF FORMS USED IN THE STUDY

1.1 Introduction

This appendix contains examples of the forms used in the study:

a. Questionnaire. This questionnaire was filled in by all subjects during session One.

b. Session Three Scoring Sheet. This form was used to record the results of the typing tests and learning tasks, for each subject.

c. Manual Record - Long Form. All the manual medical records used in the study was of this type. The records were hand written and not typed as in this example (Van den Berg 1981).

d. Manual Record - Short Form. The manual record is also available in a shorter form (Van den Berg 1985)

e. Problem Data Entry Sheet. A form like this was prepared for each of the tasks, and used to record the problem experienced by each of the subjects with the tasks. A tick mark was made in the right hand column under the subject number when a problem was identified for a particular subject.

1.2 Questionnaire

IMIS PROJECT QUESTIONNAIRE
INSTRUCTIONS

1. Computers are becoming more commonplace in Medicine, and it is therefore necessary to take a closer look at the use of and attitude to computers in this environment.

2. The information obtained from this questionnaire will be used in the evaluation of an experimental interactive medical information system. An interactive medical information system is a computer system that is intended to be used by a physician to directly enter and retrieve information from a computer while he is seeing a patient. The system was developed as part of a postgraduate reserach project at the University of Cape Town Medical School.

3. Please answer all the questions by circling the number of your choice; taking care not to include more than one number in the circle. Only one number per question can be circled. See example elsewhere on this page.

4. Only two questions (1 & 5) in Section A require you to write out your answer. Please write only one numeral in each of the blocks provided. See example elsewhere on this page.

Notes: Section A Question 3 : Circle your language of choice.
Question 5 : A part of a year counts as one year.

Examples: 1. Age | 4 | 4 | years

Voorbeelde: 11. Sal geneeskunde onpersoonlik maak. | 1 | 2 | 3 | 4 | 5 |

IMIS-PROJEKVRAELYS
INSTRUKSIES

1. Rekenaars word steeds meer in die mediese veld gebruik, en daarom is dit nodig om in hierdie omgewing van naderby te kyk na die gebruik van en houdings jeens rekenaars.

2. Die inligting wat verkry word vanaf hierdie vraelys sal gebruik word in die evaluasie van 'n eksperimentele interaktiewe mediese inligtingstelsel. 'n Interaktiewe mediese inligtingstelsel is 'n rekenaarstelsel wat bedoel is om gebruik te word deur 'n geneesheer om informasie direk op die stelsel te plaas of te onttrek, terwyl hy die pasiënt sien. Hierdie stelsel is ontwikkel as deel van 'n na-graadse navorsingsprojek aan die Mediese Skool, Universiteit Kaapstad.

3. Beantwoord asseblief alle vrae deur die nommer van u keuse te omkring. Maak asseblief seker dat u nie per abuis meer as een nommer omkring nie. Slegs een nommer kan omsirkel word per vraag. Sien voorbeeld elders op bladsy.

4. By slegs twee vrae (1 & 5) in Afdeling A hoef u u antwoorde uit te skryf. Skryf asseblief slegs een syfer in elkeen van die blokkies. Sien voorbeeld elders op bladsy.

Notas: Afdeling A Vraag 3 : Omsirkel die taal van u keuse.
Vraag 5 : 'n Deel van 'n jaar tel as een jaar.

IMIS Project Questionnaire

No: 0 1 0

A. BIOGRAPHICS

1. Age 5 6 years
2. Sex: Male (1) Female 2
3. Language: Afr (1) Eng 2
4. Highest Medical Qualification: MBChB (1) MMed 2 MD 3
5. Years after Internship: 3 4

B. RELEVANT EXPERIENCE

1. How often do you use a computer (actually working on a computer)
   (1) Never; 2 Yearly; 3 Monthly; 4 Weekly; 5 Daily

2. My knowledge about computers is:
   1 None; (2) Below average; 3 Reasonable; 4 Above average; 5 Excellent

3. Have you ever used a computerized medical record system before?
   1 Yes; (2) No

4. If "Yes" to Question B3, how often did you use it?
   1 Almost never; 2 Yearly; 3 Monthly; 4 Weekly; 5 Daily

5. Do you own a personal computer?
   1 Yes; (2) No

6. In developing computer applications in medicine, administrative applications, such as patient billing and appointments, should receive a ..... priority.
   1 Very low; 2 Low; 3 Moderate; (4) High; 5 Very High

7. In developing computer applications in medicine, clinical applications, such as medical records and clinical decision support, should receive a ..... priority.
   1 Very low; 2 Low; 3 Moderate; (4) High; 5 Very High

8. If a suitable system existed, would you be prepared to enter your own clinical notes directly on computer?
   (1) Yes; 2 Undecided; 3 No

9. Are you familiar with the problem-oriented approach to medical record keeping?
   1 Not at all; 2 A little; 3 Reasonably; 4 Above average; (5) Very familiar

C. COMPUTER ATTITUDES

Please answer all of the questions in this section according to the following scale:

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

Computerized Medical Record Systems...

1. Will increase government control of physicians' practices.	1	(2)	3	4	5
2. Will be blamed by patients for errors in management.	1	(2)	3	4	5
3. Will increase the cost of health care.	1	2	3	(4)	5
4. Will threaten personal and professional privacy.	1	2	(3)	4	5
5. Will result in serious legal and ethical problems. (eg malpractice)	(1)	2	3	4	5
6. Will threaten the doctor's self-image.	1	(2)	3	4	5
7. Will be difficult for physicians to learn.	1	2	(3)	4	5
8. Will result in reliance on cookbook medicine and the diminishing of clinical judgement.	1	(2)	3	4	5
9. Will diminish the patient's image of the doctor.	1	(2)	3	4	5
10. Will be unreliable becuase of computer "malfunctions".	1	(2)	3	4	5
11. Will dehumanize medical practice	1	(2)	3	4	5
12. Will contain information that cannot be kept up-to-date easily.	1	2	3	(4)	5
13. Will alienate physicians because of electronic gadgetry.	1	(2)	3	4	5
14. Will force doctors to think like computers.	1	2	(3)	4	5
15. Will reduce the need for paraprofessionals, such as nurses.	1	2	(3)	4	5
16. Will reduce the need for medical specialists.	1	2	(3)	4	5
17. Will result in less efficient use of a physician's time.	1	(2)	3	4	5
18. Will be inappropiate for developing countries.	1	(2)	3	4	5

Thank you for your cooperation.

Dr AJ Herbst
PO Box 6022
PRETORIA
0001 Tel (012)450-2659(W) 71-5053(H)

1.3 Session Three Scoring Sheet

Session 3 : Scoring Sheet

Subject: 3

	Sp 2A	Ac 2A	Sp 2B	Ac 2B	Sp 3	Ac 3
Typing	11	99	13	99	13	99

	Tasks	Score				
1	Select patient	1	2	3	(4)	4 = Task completed without errors
2	Open patient file	1	2	3	(4)	3 = Corrected error self
3	Create contact	1	(2)	3	4	2 = Needed help in correcting error
4	Add problem status	1	2	3	(4)	1 = Couldn't complete task
5	Add flow sheet items	1	2	3	(4)	
6	Modify contact with notes	1	(2)	3	4	
7	Add problem	1	2	3	(4)	
8	Update referral	1	2	(3)	4	
9	Add referral	1	(2)	3	4	
10	Repeat actions	1	(2)	3	4	
11	Add action	1	2	3	(4)	
12	Select subset of actions	1	2	3	(4)	
13	Graph flow sheet item	1	(2)	3	4	
14	Graph problem	1	2	3	(4)	
15	Close patient file	1	2	3	(4)	

1.4 Manual Record - Long Form

Buitepasiënte Rekordkaart

NAAM EN ADRES:
Mev R Brits
Stasiestraat 12
BOTHASDORP

Geboortedatum: 150627

Huwelikstaat: Getroud Tel No's:

Gesinshoof: Mnr H J Brits

Aantal persone in huishouding: 2 : 1

Huidige beroep: Huisvrou

Vorige beroepe:

A. ALGEMENE KLINIESE NAVRAAG: DATUM VAN NAVRAAG: 810203 OUDERDOM VAN PASIËNT: 53

Is daar by navraag enige tersaaklike gegewens ten opsigte van huidige of vorige geskiedenis m.b.t. die volgende?
Merk met "X" in die betrokke kolom.

No.		JA	NEE	No.	OMSKRYWING VOLGENS NOMMERS
1.	Kongenitale afwykings		X		
2.	(By kinders): Groei, ontwikkeling, skoolvordering, voeding				
3.	Ongelukke, beserings		X		
4.	Vorige operasies	X		4	Appendektomie 1950
5.	Infektiewe of aanmeldbare siektes		X		
6.	Vorige medikasie van belang	X		6	Tevore op alfa-metieldopa
7.	Gewoontes m.b.t. alkohol, tabak, wangebruik van geneesmiddels		X		
8.	Slaapgewoontes, eetgewoontes, oefening, ontspanning		X		
9.	Afwykings van Liggaamsmassa	X		9	Toename, 15 kg in 10 jaar
10.	Allergieë	X		10	*Penisillien-allergie*
11.	Familiegeskiedenis	X		11	Moeder oorlede aan diabetes mellitus
12.	Huislike omstandighede, huwelikspro-bleme		X		

Immunisasie: Wat is gedoen? Pokke, polio, tetanus

Spesiale ondersoeke gedoen: Datums en resultate: Ba/maal, 1978. Hiatus hernia
Rö : Lumbosakraal-area, 1980. Diskusletsel L5 - S1

B. SISTEMATIESE KLINIESE NAVRAAG:

As daar by navraag enige tersaaklike gegewens ten opsigte van huidige of vorige geskiedenis m.b.t. die volgende?

No.		JA	NEE	No.	OMSKRYWING VOLGENS NOMMERS
1.	Neurologiese afwykings		X		
2.	Huid		X		
3.	Oë en visie		X		
4.	Ore, Neus en Keel	X		4	Herhaalde tonsilitis
5.	Respiratoriese stelsel		X		
6.	Kardiovaskulêre stelsel	X		6	Tevore behandel vir hipertensie
7.	Spysverteringstelsel	X		7	Hardlywig. Dispepsie, veral snags. Aambeie : erger as sy hardlywig is.
8.	Anemie, vergrote kliere of milt, tumore		X		
9.	Borste		X		
10.	Spier-sketelstelsel	X		10	"Rumatiek" in veral knieë, heupe en skouers. Lae rugpyn met wortelpyne in linker dy.
11.	Endokriene stelsels: Tireoïed, diabetes mellitus, andere		X		
12.	Urienwcë, genitalicë en prostaat		X		

B SISTEMATIESE KLINIESE NAVRAAG (Vervolg)

Is daar by navraag enige tersaaklike gegewens ten opsigte van huidige of vorige geskiedenis m.b.t. die volgende?

No.		JA	NEE	No.	OMSKRYWING VOLGENS NOMMERS
13.	Psige: Angs, depressie, epilepsie, psigoses	X		13	Voel depressief - sy meen dis a.g.v. oormassa
14.	Ander probleme en afwykings		X		
15.	By vroue: Ginekologiese of obstetriese probleme		X		

Datum van laaste menstruasie: 1975 Aantal en ouderdomme van kinders: 3 : 24, 21, 17

C. SISTEMATIESE ONDERSOEK:

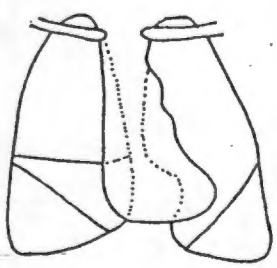
Massa 80 Lengte 160 cm. Temp. 38,5°C Polstempo 100 /min. Ritme Gereeld BD. 160/105 mm Hg

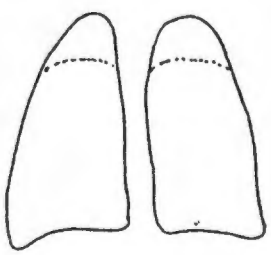
Is daar by ondersoek tersaaklike bevindinge m.b.t. die volgende? Merk met "X" in die betrokke kolom en omskryf waar nodig.

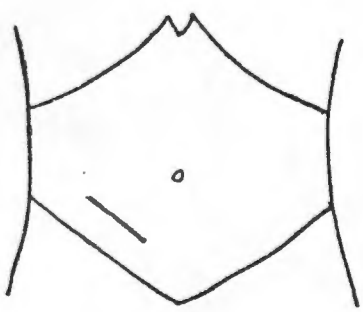
No.		JA	NEE	No.	OMSKRYWING VOLGENS NOMMERS
1.	Voedingstoestand, algemene voorkoms en velkleur	X		1	Oormassa
2.	Kop, nek en tiroied	X		2	Vergrote submandibulêre limfkliere
3.	Tande, mond, lippe en tong		X		
4.	Vel, hare en naels		X		
5.	Oë, visie, fundoskopie		X		
6.	Ore, Neus en Keel	X		6	Keel rooi. Etter op mangels
7.	Borskas en borste		X		
8.	Longe (Dui aan op tekeninge)		X		
9.	Hart (Dui aan op tekeninge)		X		
10.	Buik, bekken en breukpoorte (Dui aan op tekening)	X		10	Appendesektomie - litteken. Verder normaal
11.	Rektale ondersoek	X		11	Graad II inwendige aambeie
12.	Vaginale ondersoek				
13.	Genitalia				
14.	Limfkliere, milt		X		
15.	Spinale kolom, ledemate en gewrigte	X		15	Osteoartrose in genoemde gewrigte. Drukteer oor lumbosakrale area
16.	Perifere sirkulasie, Arteriee en Veneus		X		
17.	Neurologies: Sensasie, Reflekse, Motories		X		
18.	Psige, intellek en emosies	X		18	Depressief
19.	Ander bevindinge				

Urienondersoek: Glukose +

Hemoglobien: Ander sykamer-ondersoeke: Toevallige B.S. 10 m.mol/L







AKTIEWE REKORDVEL

DATUM	VERLOOP VAN BESTAANDE PROBLEME, NUWE BEVINDINGE EN PROBLEME, VERWYSINGS EN BEPLANNING (Nuwe probleme : Merk met volgnommer in 'n [ ])	BD	M	Toev. BS	BEHANDELING
810203	Hoofklagte: Akute seerkeel, hoofpyn, + koors, 2 dae [12] Akute tonsilitis Plan: Besluit later oor ton=silektomie as nodig. Volg bloed=druk, massa, bloedsuiker en ander probleme op	160/105 P.96	80	10.0	℞ *a* Eritromisien 500 mg 2x/d *b* Parasetamol 2 vir pyn *c* Diëet: 4 000 Kj diabetiese diëet, hoë vesel + soutbeper=king *d* Metoklopramied a.c. *e* Naproksien p.c. *f* Scheriproct-salf
810210	Beter : 12 *Glukose-toleransiekurwe* Diabetiese patroon	155/105	78,5	8,5	Gaan voort met c - f *g* Oefening: Gereelde stap
810310	Beter: 5,6,8,9 [12] Do : 7 Erger: 10 (slaap ook sleg) Kla van disurie en frekwensie *Urien:* Albumien + Etterselle + organismes ++ [13] Urienweginfeksie *M, K + S* E. coli Plan: Volg op na 1 week	155/105	76	8,5	*h* Ko-trimoksasool 2, 2x/d, 5 dae Herhaal c - f ℞ *i* Amitriptilien 50 mg saans *j* Codis 1 - 2 vir pyn
810317	Beter: 5,6,7,8,10,13 Do: 9 Erger: - B.O. : Nog pyn en teerheid in l.nierhoek *I V P* Plan: Verwys as nodig na uroloog	150/100	75	7,0	Herhaal c - i Staak j

PROBLEEMLYS

NO.	OORGEDRAAGDE PROBLEME	AKTIEF	ONAKTIEF	DATUM OPGETEKEN	WANNEER ONTDEK	DATUM OPGELOS
1	Oormassa	X		810203	± 1971	
2	*Penisillien-allergie*		X	"	?	
3	Herhaalde tonsilitis			"		
4	Hipertensie			"	1979	
5	Dispepsie : Hiatus hernia			"	1978	
6	Aambeie			"	1980	
7	Hardlywigheid			"	± 1975	
8	Osteoartrose : Veral knieë, heupe, skouers			"	± 1975	
9	Lae rugpyn : Diskus L5 - S1			"	1980	
10	Depressie			"	1980	
11	Diabetes mellitus			"	810203	

INSTRUKSIES BY GEBRUIK VAN PROBLEEMGERIGTE REKORDSTELSEL

ALGEMENE BEGINSELS:

Die basiese uitgangspunt is om pasiënte se probleme te identifiseer, 'n lys daarvan te hou, die verband tussen probleme te soek, en dit in die regte perspektief m.b.t. dringendheid en belangrikheid te sien. Teenoor die probleemlys staan die lys van toepaslike terapie as deel van probleemhantering en -oplossing. 'n Ordelike patroon van probleemgerigte denke is nodig vir omvattende, deurlopende pasiëntesorg.

EERSTE BESOEK:

Besluit self of prosedure 1 of 2 hieronder, eerste gevolg moet word:

1. Noteer hoofklagtes en uiteensetting daarvan in die kolom vir "aktiewe rekords", bls. 3
2. Voltooi "Algemene navraag", probleme, ens, "Sistematiese navraag" en "Sistematiese ondersoek":
   (a) Merk met "X" in die "JA" of "NEE"-kolom. Laat die ruimtes oop waar navraag of ondersoeke nie gedoen is nie. Indien "JA", skryf die betrokke syfer langs die kant van die ruimte vir omskrywing in lyn met waar staan "No."
   (b) Beskryf die gegewens kort en bondig (sien voorbeeld)

	JA	NEE	No.	
1.		X	3	Hoofbesering, 1976. Geen nagevolge. Fraktuur femur 1978.
2.				
3.	X		5	Malaria 1979. Een aanval. Tuberkulose 1975, Tans genees
4.		X		
5.	X			

   (c) Volg dieselfde beginsels by "sistematiese navraag" en "sistematiese ondersoek"
3. (a) Formuleer *onopgeloste* PROBLEME wat tydens algemene en sistematiese navraag en ondersoek geïdentifiseer is, en teken een vir een aan langs blokkies op die PROBLEEMLYS. Nommer met blokkies. (Sien voorbeeld hieronder):

PROBLEEMLYS

	Oorgedraagde probleme	Aktief	Onaktief	Datum opgeteken	Wanneer ontdek	Datum opgelos
1	Rook	X		26.8.81		
2	Penisillien allergie		X	do	1970	
3	Oormassa	X		do	1972	
4	Huweliksprobleme	X		do	1980	
5	COLS	X		do	1972	
6	Hipertensie	X		do	1974	
7	Osteoartrose		X	do	1976	
8	Depressie	X		do	1980	

   (b) Indien dit wat in hoofklagtes genoem is, nie reeds tydens die sitematiese navraag en ondersoek as deel van die probleemlys opgeneem is nie, formuleer ook die huidige *hoofklagtes* as *probleme*.
   Teken dit aan in die "kliniese kolom" teenoor een of meer vierkante bedoel vir volgnommers. Ken dan ook toepaslike volgnommers daaraan toe, in 'n ander kleur, bv. rooi. (Sien voorbeeld)

Datum	Kliniese gegewens, nuwe probleme opvolgnotas	Massa	B.D.	Behandeling
26.8.81	*Hoofklagtes:* Substernale pyn met inspanning en ná maaltye. Versprei na linker arm 9 ? Angina pectoris EKG Serum lipiede *Plan:*	86.4	190/110 P. 80	Neem reeds a ..... b ..... c ..... Staak b Staak rook R d ..... Herhaal a,c

N.B. Nuwe probleme word nie dadelik op die probleemlys aan die boent van die bladsy aangeteken nie, maar wel in die kliniese kolom soos op die voorbeeld aangedui. (9 ...)
Wanneer 'n nuwe probleem ooglopend tydelik van aard is, bv. "verkoue", maak slegs 'n vierkant bv. " ☐ Verkoue"

4. Waar opvolghantering benodig word, teken afwykende parameters bv B.D., massa, in vertikale kolomme links van die middelste vertikale lyn aan. (Sien voorbeeld)

5. *Behandeling:*
   (a) Noteer middels wat alreeds gebruik word in die behandelingskolom. Skryf dit ondermekaar. Lys middels alfabeties, nl. a, b, c, ens. in 'n ander kleur wanneer dit vir die eerste maal opgeteken word.
   (b) Wanneer 'n middel gestaak word, trek 'n penstreep deur die letter wat dit voorafgaan, bv "~~a~~ Parasetamol".
   (c) Noem ook ander behandeling, bv "dieet", "fisioterapie" ens.

6. *Spesiale ondersoeke aangevra:*
   Noteer in "kliniese kolom" in 'n ander kleur. Laat ruimte vir latere inskryf van verslae.

7. Dieselfde reël geld vir verwysings na konsultante.

8. "*Plan*": Indien toepaslik, sluit kliniese kolom hiermee af, bv 'behandel eers ..., verwys later na chirurg vir ..."

OPVOLGBESOEKE:

1. Teken opsommende verslae van spesiale ondersoeke of verwysings betrokke by die vorige besoek aan in ruimtes daarvoor gelaat.

2. Gaan die lys van aktiewe probleme na en teken bevindings soos volg aan:

Voorbeeld:

23.9.81	Beter: 1, 4, 8, 9 Dieselfde: 5, 7 Erger: — Plan:	BD 150/105	Massa 83 Kg	Herhaal a, c, d, R e .....

3. Teken benodigde verdere spesiale ondersoeke en/of verwysings aan.

4. Formuleer verdere plan/ne indien nodig en teken dit aan.

5. *Terapie:* Vir herhalings, gebruik simbole bv "Herhaal a, c. Staak d. R e .....

AS OPVOLGBLADSY VOLGESKRYF IS, EN OMGEBLAAI MOET WORD:

1. Skryf terapie wat nog toegedien word oor op die volgende bladsy. *N.B.* Gee nuwe letter-simbole daaraan (om terugblaai onnodig te maak). Begin dus weer met a, b, c ens. in 'n ander kleur.

2. Dra *onopgeloste* probleme op hierdie bladsy, met korrekte volgnommer daaraan toegeken, na die probleemlys oor.

V&R Pta. 10458

1.5 Manual Record - Short Form

BASIC RECORD CHART

Drs: .....

PATIENT: Mr/Mrs/Miss/Child: . R. JONES ..... Marital status: . Married .....

ADDRESS: .40 Church Street, Westville ..... Number of persons in household: .2 + 1 .....

Date of birth: 150629 Patient No: 0914 Occupation: .Housewife .....

A. GENERAL CLINICAL QUESTIONNAIRE: Date of questionnaire 850203

Is there any relevant information from the present or previous history with regard to:

	YES	NO	No.	Description according to No's
1. Congenital problems, growth, progress		X		
2. Injuries, operations	X		2.	Appendicectomy, 1950
3. Infective diseases, rheumatic fever		X		
4. Tobacco, alcohol dependency		X		
5. Habits, sleep, diet, exercise	X		5.	Bad sleeper, inactive
6. Change in body weight	X		6.	1 Body mass, 15 kg over 10 years
7. Allergies	X		7.	Allergy: Penicillin
8. Family history	X		8.	Mother: Diabetes mellitus
9. Family and marriage		X		

Immunization: Smallpox, Polio, Tetanus

Special examinations. Dates and results:
Rö: Lumbosacral, 1980: disc L5-S1

B. SYSTEMATIC CLINICAL QUESTIONNAIRE:

Is there any relevant information from the present or previous history with regard to:
(indicate with an 'X' in the appropriate column and describe)

	YES	NO	No.	Description according to No's
1. Neurological		X		
2. Skin		X		
3. Eyes, vision		X		
4. Ears, nose, throat	X		4.	Recurrent tonsillitis
5. Respiratory		X		
6. Cardiovascular	X		6.	Previously treated for hypertension
7. Gastro-intestinal		X	7.	Constipated, piles
8. Anaemia, glands, spleen, tumours		X		
9. Breasts		X		
10. Endocrine		X		
11. Urogenital		X		
12. Muscle, joints, skeleton	X		12.	Pain in knees, hips and shoulders. Low backache — root pains left thigh
13. Psyche, emotions	X		13.	Depressed
14. Gynaecology, obstetrics		X		

Date of last menstruation: . .1975 .....

Number and age of children: . Three: 24, 21, 17 years .....

C. SYSTEMATIC EXAMINATION:

Mass 80 kg; Height 160 cm; Temp 38,5° C; Pulse 100/min; BP 160/106 mmHg

Is there any relevant information with regard to:
(mark the relevant column with an 'X' and describe where necessary)

	YES	NO	No.	Description according to No's
1. Appearance, nutrition	X		1.	Overweight
2. Head, neck, thyroid	X		2.	Enlarged submandibular glands
3. Teeth, mouth, lips, tongue		X		
4. Skin, hair, nails		X		
5. Eyes, vision, fundoscopy		X		
6. Ears, nose, throat	X		6.	Throat red. Pus on tonsils
7. Chest, breasts		X		
8. Lungs		X		
9. Cardiac		X		
10. Peripheral vessels (A+V)		X		
11. Abdomen		X		
12. Rectal	X		12.	Piles, Gr. II, internal
13. Urogenital				
14. Vaginal				
15. Muscles, joints, skeleton	X		15.	Pressure tenderness in L-S region
16. Neurological		X		
17. Psyche, intellect	X		17.	Moderately depressed
18. Other abnormalities		X		

Urinary examination: Glucose +

Haemoglobin:

Other side-room examinations: Random blood sugar 10 mmol/l

Other comments:

PROBLEM LIST

1	Overweight	7	Osteo-arthrosis: Knees, hips, shoulders
2	*Allergy: Penicillin*	8	Low backache: disc L5-S1
3	Recurrent tonsillitis	9	Depression
4	Hypertension	10	Diabetes mellitus
5	Piles		
6	Constipated		

ACTIVE RECORDS

DATE	INITIAL PROBLEMS (MAJOR COMPLAINTS) NEW PROBLEMS AND FINDINGS PLANS	FOLLOW-UP OF PROBLEMS SPECIAL EXAMINATIONS, REFERRALS (New problems: mark next to margin)	BP (mmHg)	Mass kg	Random BS (mmol/l)	TREATMENT (Alphabetical serial numbers in red)
850203	Major complaint: Acute sore throat, headache, fever, 2 days Examination: 11 Acute tonsillitis Plan: Decide about tonsillectomy if indicated at a later stage. Manage blood pressure, mass, blood sugar and other problems (The 11 is deleted on 850310)		160/105 P.96	80	10,0	R *a.* X-mycin 500 mg twice daily *b.* Painkill, 2 for pain *c.* Diet: 4 000 kJ Diabetic diet, high-fibre + salt restriction *d.* Rumagesic 1.a.c. *e.* Pile suppositories
850210	Better: 11 *Glucose tolerance level* Diabetic pattern (Highest score 14,0 mmol/l) (This result is entered on 850310)		155/105 P.72	78,5	8,5	Discontinue a, b. Continue with c, d, e. *f.* Exercise: Regular walking
850310	Better: 5, 7, 8 11 Do: 6 Worse: 9 (also sleeps badly). Complains about dysuria and frequency *Urine:* Albumin + Pus cells +, organisms ++ 12 Urinary tract infection *M, C + S* *E. coli* (Entered on 850317) Plan: Follow-up after 1 week.		155/105 P.84	76	8,5	*g.* Sulphonamide 2 twice daily for 5 days Repeat c - f R *h.* Tricycline 50 mg evenings *i.* 'Painkill' tablets, 2 for pain
850317	Better: 5, 6, 7, 9, 12 Do: 8 Worse: — OE: Pain and tenderness in left groin *Contrast studies of urinary tract* Plan: Refer to urologist if necessary		150/100 P.72	75	7,0	Repeat c - h, Discontinue i

BS = blood sugar.
P = pulse.

1.6 Problem Data Entry Sheet

	Computer Retrieval								
No	Open the file of Mrs PC Naudè	1	2	3	4	6	101	103	104
	A: Open the correct File	X					X	X	
1	Clicked twice on selected record by mistake	X					X	X	
2	Difficulty with mechanism to show menu						X		
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

	Computer Retrieval								
No	Which problem was added on 30/3/84	1	2	3	4	6	101	103	104
	A : "Hiperventilasie sindroom"								
1	Difficulty in selecting correct icon						X		
2	Inappropriate use of "Search" command.	X	X	X		X	X	X	X
3	Looked at wrong component of record		X						
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

EVALUATION METHODOLOGY

1 Preparation Phase

1.1 Task Analysis

A representative set of benchmark tasks forms the basis of the methodology. As far as the evaluation of medical record systems is concerned the benchmark tasks described in chapter 3 should be sufficient. Where other systems are evaluated such a set of tasks should be created. The creation of a benchmark set of tasks is beyond the scope of this description.

1.2 Subject Selection

A representative set of subjects need to be selected. They should be real or potential users of the system under investigation. The amount of time needed per subject (5 - 6 hours) limits the number of subjects that can be accommodated. As shown by this investigation relatively few subjects can provide an adequate amount of information. In order to prevent undue stress on the part of the subjects, it is important to reassure them that the aim of the exercise is to evaluate the computer system, and not to evaluate their performance. If the methodology is used to compare two systems, subjects should be reasonably experienced in using both the systems.

1.3 Sample Data

A data set needs to be collected. This data is used by the subjects in executing the benchmark tasks. Care must be taken to select the data in such a way that all the functions of the system can be used. This normally means that relatively complex cases must be selected.

2 Training Phase

An interactive training technique with one instructor per subject is preferred as it reduces the time required for training, and allows the adaptation of the training process to the skill level of each subject. If possible the same instructor should train all subjects. The instructor works through a fixed program with each subject.

2.1 Training to use the Computer

The first stage is to train the subjects to use the underlying computer system. This phase should include a typing skill test and typing training if the subject's skill is below a predefined level (e.g. 10 words per minute). A list is made of the features/concepts the subject needs to know and a program is drawn up based on that. If possible, use should be made of interactive training facilities on the computer system itself. The instructor uses this program to give individualized training to each subject.

2.2 Training to use the System

A training program is set up based on the benchmark set of tasks previously identified. The training starts by explaining an explicit conceptual model of the system to the subject. This is followed by a demonstration by the instructor of a how a typical case is handled. The aim here is to provide the subject with an overall impression of how the system works. The subject now operates the system and a second sample case is slowly worked through with the instructor explaining standard techniques as they are encountered. This is followed by a third sample case, which the subject attempts to do on his/her own. The instructor helps with and explains any function where the subject has difficulties. The last case is used to evaluate the teaching process. The subject again tries to execute the benchmark set of tasks on his/her own, but this time the instructor records the subject's performance in the following fashion on form 1:

a. If the task was completed without errors four points are given.

b. If the subject made an error in the execution of the task which was corrected by the subject without assistance and the task was then completed successfully three points are given.

c. If the subject made an error in the execution of the task which was corrected with the assistance of the instructor and the task was then completed successfully two points are given.

d. If the subject could not complete the task successfully one point is given.

At this stage the subject may be given a manual to study. In this case the subject is ask to record the time spent using the manual.

2.3 Example Protocol

For the medical record system this series of capture tasks was done for each sample case during training.

2.3.1 Contact Identification

It is consultation x on date y

2.3.2 Problem Status

Problem "name" has improved or stayed the same or worsened or terminated

2.3.3 Flow sheet Entries

Entry "name" value x

2.3.4 Notes

Enter the following notes: "xxxxx"

2.3.5 Problems

Problem "name" newly identified

2.3.6 Referrals

Patient referred for "name" to "x" with intention "y"

2.3.7 Actions

Previous medication repeated "x,y,z", with modification "x". Medication "s" added.

2.3.8 Additional tasks

2.3.8.1 Select subset of medications

2.3.8.2 Graph flow sheet entry

2.3.8.3 Graph problem

3 Experimental Phase

During this phase the subjects execute the benchmark set of tasks while their performance is recorded.

3.1 Recording the Performance

The composite video output of the terminal is taped using a video recorder. The audio track on this recording is used to record the prompts of the experimenter and the responses of the subject. If required, a portable video camera may be used to make a frontal recording of the subject. If this is done, a way should be found to synchronize the two recordings. Attempts

should be made to record a time code (display) as part of the video image, as it simplifies task timing considerably. This can be easily accomplished if the system being tested is able to display the time digitally somewhere on the display. This display will then become part of the composite video image being taped.

3.2 Doing the Experiment

The experiment is started by asking the subject to repeat the typing test. In addition to documenting the typing performance of the subject at the time of the experiment it also allows the subject to settle down and the surroundings to become less distractive to the subject. In the case where two systems are compared, task groups should be arranged in such a way as to avoid practice effects. The experimenter prompts the subject to do each task. Care should be taken to ensure a clearly defined end point for each task verbally or with an action on the screen. The experimenter may assist the subject in case of difficulties, by giving just enough information to allow the subject to carry on with the task, or to correct an error. In order to limit the stress experienced by the subject, the experimenter should give the prompts calmly and slowly with a level tone of voice. The experimenter should try to keep body movements to the minimum without appearing unnatural.

3.3 Example Protocol

3.3.1 Sequence

a. Typing Test

b. Retrieval Manual

c. Capture Computer

d. Rest period

e. Retrieval Computer

f. Capture Manual

3.3.2 Content

3.3.2.1 Retrieval Structure

3.3.2.1.1 Patient

Identify patient.

3.3.2.1.2 Problem

a. State the problem that was added on a particular date

b. State the date on which a particular problem was added

c. State when a particular problem was terminated

3.3.2.1.3 Problem Status

a. Determine the status of a problem at a given date

b. Determine the status of the problem the last time it was addressed

3.3.2.1.4 Progress Note

a. Read the text of the contact (Contact identified by date)

b. Identify the contact that contains a given statement by date.

3.3.2.1.5 Actions

a. Name all the medications given at certain date

b. When was a certain medication last given

3.3.2.1.6 Referrals

a. When was the last referral for a specified reason

b. Has the result for a specified referral already been received

3.3.2.1.7 Flow sheet Entry

a. Give the value of a named entry at a certain date

b. When did a named entry have a specified value

3.3.2.1.8 Structured tasks

a. What happened to problem x when the patient received treatment y

b. Has a particular problem improved/worsened over time

c. When and what was the change in dosage in treatment x

d. How many referrals of a particular kind were there?

3.3.2.2 Capture Structure

a. Select Patient

b. Contact Identification

c. Problem Status

d. Flow sheet Entries

e. Notes

f. Problems

g. Referrals

h. Actions

4 Analysis Phase

Two passes are made through the recorded material. During the first pass task times are determined and during the second pass problems are identified.

4.1 Task Measurements

Tasks are defined and measured as described in Chapter Three, paragraph 3.2.3.1.3. With reference to figure E.1 times are measured as follows:

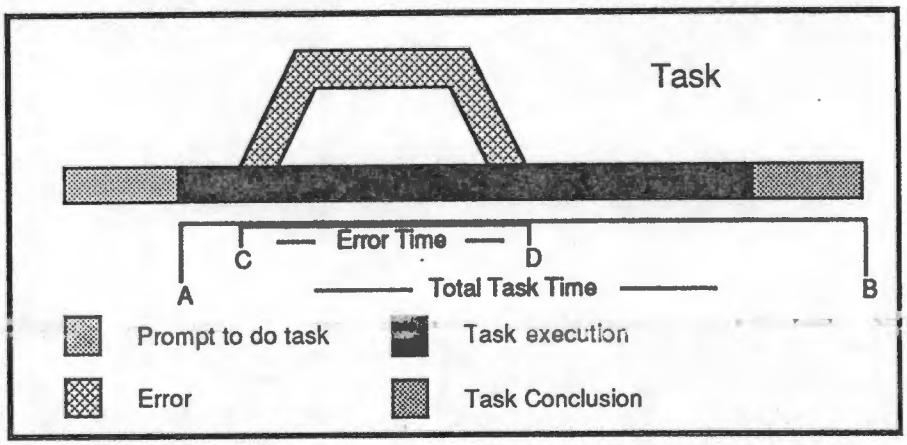


Figure E.1. Task Components

a. Total Time. The difference in time between point A and B.

b. Error Time. The difference in time between point C and D. If more than one error occurs during a task, the times are added together.

c. Error Free Time. The difference between the values obtained in *a* and *b*.

Times are best recorded by noting down the time displayed at points A, B, C and D while watching the recording. The pause and rewind functions of the video recorder are used often during this process. The differences can be calculated at a later stage to obtain the final measurements.

4.2 Problem Identification

Problem identification is done during the second pass through the recordings. The actions of the subject are observed to determine possible problems, e.g. hesitations in the execution of the tasks. When a problem is identified it is noted on a form 2 and a cross is made under the

number of the subject experiencing the problem. The descriptions given to problems should be descriptive and no attempt should be made at this stage to interpret or to describe the cause of the problem.

If the benchmark tasks involved information retrieval this pass is also used to check whether the answers given by the subject are correct. During this pass the data collected in the first pass can be checked for correctness.

The problems identified are listed and similar problems are grouped together and renamed if necessary.

4.3 Problem Classification

This stage is still problematical because no generally accepted and useful classification exists. Interested readers are referred to the literature (Arnold & Roe 1987; Rasmussen, Duncan & Leplat 1987; Miller & Swain 1987; Norman 1983) or to the classification used in this study (Chapter 6, par 6.3.7)

5 Design Phase

During this phase the conclusions for the design of the system are drawn. Appendix C gives an example of how it can be done. Changes can be made based on the following:

a. Problems. Individual problems often point to improvements which can be made to the user interface of the system. The number of times a problem is a experienced gives an indication of the importance of the change.

b. Task Times. Tasks that take too long.

c. Error Time. If a large percentage of the task time is taken up by errors.

d. Problems per Task. Tasks with a large number of problems.

e. Difference with Reference System. In the case where two systems are compared, a large difference in tasks times between systems.

6 Forms

6.1 Form 1: Training Score Sheet

Training Score Sheet

Subject ☐☐☐

	Tasks	Score
1.	Select **patient**	☐
2.	Open patient **file**	☐
3.	Create contact	☐
4.	Add problem status	☐
5.	Add flow sheet items	☐
6.	Modify contact with notes	☐
7.	Add problem	☐
8.	Update referral	☐
9.	Add referral	☐
10.	Repeat **actions**	☐
11.	Add action	☐
12.	Select subset of **actions**	☐
13.	Graph flow sheet item	☐
14.	Graph problem	☐
15.	Close patient file	☐

1= Couldn't complete task
2= Needed help in correcting error
3= Corrected error self
4= Task completed without errors

6.2 Form 2: Problem Identification Sheet

Problem Identification Sheet

No	*Task Name* Subject Nos →	1	2	3	4	5	6	7	8	9	10
1	The first problem of *task name*	x				x	x			x	
2											
3											
4											
5											
6											
7											
8											
9											
10											

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