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The Presentation of a Model of an Electronic Patient Record System for use in General Practice in South Africa

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THESIS

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Dedicated to my parents:

- To the loving memory of my mom, Elsa Joubert, who in her relatively short life taught me what it really meant to live one's life to the fullest

- To my dad, Peet Joubert, who has been an enthusiastic source of encouragement throughout my whole life and who always believes in me - even if I sometimes do not.

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Chapter 1

Introduction

1.1 Introduction

Information drives the practice of medicine. Clinical information can be defined as "the commodity used to help make patient care decisions" [Wyatt 1996]. Physicians must use it every time they see a patient, perform a procedure, or consult a colleague [Tonks 1996]. To meet the needs of patients, they need to draw on the knowledge accumulated by medicine over the past 500 years. Medicine is a knowledge-based business. Unfortunately, the sheer size of this medical knowledge base poses a forbidding problem for the healthcare practitioner. Opinions vary, but it is believed that there are in excess of five million medical facts. Experienced physicians use about two million pieces of information to manage their patients [Pauker 1976; Wyatt 1991; Smith 1996]. New research projects and research results, that are published in more than 30,000 biomedical journals, add to this number, whilst at the same time discrediting, altering or extending some of the existing facts. The average student can master five to ten facts per hour under good conditions, but rapidly loses knowledge that is not reinforced by regular use. This brings about the daunting perception that more than two hundred years of full time study is necessary just to master medical knowledge as it stands today [Neame 1995]. It is also believed that medical knowledge will increase fourfold during a professional lifetime [Hersch 1995].

Physicians keep most of the information that is used when seeing patients in their heads. Unfortunately, some of the information in the physician's head is wrong and outdated. New information may not have penetrated and therefore may not be there to deal with patients with uncommon problems [Smith 1996]. This information explosion indicates that

medical practitioners desperately need assistance in order to stay informed, to be productive and to provide quality health care to their patients [Ornstein 1997]. The latter implies that they do not only need to keep up with existing and new medical facts (external information explosion), but they need to keep track of all the data created as part of day-to-day patient consultations (internal information explosion). Personal details of every patient, the medical history of the patient, data resulting from the physical examination of each patient, and the subsequent diagnosis could be processed into priceless information. Without the assistance mentioned above, this potential useful information will, however, remain useless data items. Consequently physicians drown in the resultant medical facts of the *external* and the *internal* information explosion. This study will focus specifically on the processing of the internal information. The creation of the patient record was the first step in trying to bring order to this internal information.

The contents of this thesis cover two subject areas, namely Computer Science and Medicine. After conducting a literature study on the history and development of the patient record, research will be directed towards identifying problems associated with current paper medical records, as well as the requirements, expectations, and needs regarding electronic patient record (EPR) systems as seen from the viewpoint of general practitioners in South Africa. If such needs exist, prototype EPR systems will be designed and presented for evaluation and testing, after which a usability assessment will be conducted. The ultimate goal of the thesis is to present the general practitioners of South Africa with a model of a proposed EPR system, designed for their specific requirements, expectations, and needs.

In the following section a brief history of the development of the patient record will be given.

1.2 The origin / history of the patient record

The patient record has probably existed ever since people with medical skills reported on a patient's course of disease and treatment. Physicians have always collected and stored data on their patients. This data served as a memory aid for ongoing diagnosis and management in the provision of continuing medical care. The Hippocratic case record, one of the first known medical records, was a time-oriented record in the purest sense. It described the condition of the patient prior to his current illness, followed by the sequence of symptoms that led him to seek help. From thereon, the record contained narratives that related signs and symptoms, until the patient was cured, or died. Each narrative mentioned the number of days that has passed since the patient's last consultation [Reiser 1991a].

For centuries records continued to be written in the Hippocratic style, with emphasis on the patient's phrasing of the symptoms. In 1819 the focus of the patient record changed from the observations of the patient to the observations of the physician. The medical notes were brief comments, used by their author to trigger fuller recollections of the patients involved. Privacy and ethical/legal issues were of the utmost importance: accessibility of the information to others was neither desired nor desirable. This lack of availability and communication of health information in the provision and evaluation of health care have been recognised for a long time [Liaw 1993]. In 1863 Florence Nightingale [Nightingale 1863] wrote, "In attempting to arrive at the truth, I have applied everywhere for information, but in scarcely an instance have I been able to obtain hospital records fit for any purposes of comparison. If they could be obtained...they would show subscribers how their money was being spent, what amount of good was really being done with it, or whether the money was not doing mischief rather than good...".

After founding St. Mary's Hospital in Rochester in the 1880s, surgeon William Mayo and his sons started a group practice, the forerunner of the Mayo Clinic. The Mayo Clinic, as it is known today, is a co-operative group of physicians with various specialities. From 1885 until 1907 it was customary for physicians in the Mayo Clinic to record patient

information in leather-bound ledgers. The attending physician, the surgeon, and the laboratory each kept their own set of ledgers. Each physician ledger was a chronological account of his/her findings and actions. Hence, the contents were time-oriented per physician: the notes pertaining to an individual patient could be on separate pages, depending on the time between subsequent visits. It is clear that tracing a patient's case history was a laborious task. Plummer therefore introduced a single record per patient in 1907 [Kurland 1981].

In the 1920s missing data and the absence of a standardised method of recording, led to a proposal to enforce physicians to note certain essential data. Although this proposal met with a lot of resistance, the standardised portion began to serve as a framework for the record as a whole [Reiser 1991b].

The clinical data was based on the task, person performing the task and/or the encounter. Because of this diversity, there was general disagreement among physicians as to how the data should be ordered in the record. In many patient records, the notes were a mixture of observations, interpretations, treatment, and test results. Such unstructured notes obscured the underlying motivations and casual relationships. Weed, therefore, introduced the A4-folder problem-oriented medical record (POMR), in which all notes are recorded in the context of a specific problem [Weed 1964]. Problems are defined on the basis of an inventory of symptoms and signs. The notes are organised per problem according to the SOAP-model (**S**ubjective, **O**bjective, **A**ssessment, **P**lan), which helps to elucidate the physician's line of reasoning.

The POMR has been adopted as the standard for record-keeping on paper by many physicians in Australia, the United Kingdom (UK), the rest of Europe, North America and also in South Africa [Liaw 1993]. Despite the fact that the POMR has attracted devoted apostles, it has equally passionate opponents. It has been stated that the POMR requires redundant reporting when findings pertain to more than one problem. This may obscure relationships between problems [Fernstein 1973; Tange 1994]. Another effect of the

POMR is that records become more bulky, with repetition of data and obscuring of trends [Wyatt 1998]. Empirical studies showed unchanged speed and accuracy of data retrieval compared to standard records [Fletcher 1974]. A randomised clinical trial confirmed that the problem-oriented format was insufficient to improve clinical practice [Fernow 1978].

Wyatt and Wright [1998] advocate that, instead of offering "simple" solutions such as "organise medical record data by patients' problems", physicians who create records and design proformas, report forms, or complete record systems should choose data formats and document layouts that will help record users to find and interpret the data in the context of their clinical use. To ensure that the format of clinical documents is as reliable as their contents, the designers of records, knowledge resources, and other clinical information systems need to tap their skills in psychology, graphical design, perception, and typography. This should contribute towards more accessible and usable information [Wyatt 1999].

1.3 Current paper medical records

What does a patient record (also referred to as a medical record) generally entail today? A patient record is a confidential record that is kept for each patient by a health care professional or organisation. It contains the patient's personal details (such as name, address, and date of birth), a summary of the patient's and his/her family's medical history, and documentation of each event (collection of the physician's notes), including symptoms, diagnosis, treatment and outcome (interpretation). Insurance information is also documented [Olsen 1995]. Relevant documents and correspondence are included, as well as images and graphs. Traditionally, each health-care provider involved in a patient's care has kept an independent record, usually paper-based – from there the term *paper medical record (PMR)*. These PMRs are usually considered to be static, time-sequenced, and owned by the institution or practice where it is stored. The main purpose of the patient record is to provide a summary of a person's contact with a healthcare provider and treatment provided to ensure appropriate healthcare [Neame 1995].

According to Lambert *et al.* [1993], an individual patient's medical record can be considered as the logical collection of relevant patient clinical information that extends across all physical records that pertain to the individual patient. The reason for this is that a patient's medical record is usually based on his/her memory, summarised and filtered, both by the patient's understanding of the clinical events that have occurred, and by the patient's recall of the details [Neame 1995].

What most modern PMRs have in common is a nested ordering: the documents that make up the PMR are ordered by source, and within each source, by time. In this context, the term "source" denotes the type of data, e.g. letters, progress notes, laboratory results, X-ray reports, and pathology reports, and not their author. Depending on how the record is used, data within a source are ordered from past to present, or vice versa. Progress notes may further be organised in a problem-oriented SOAP model [Van Ginneken 1995].

1.3.1 Strengths of the PMR

The PMR has some special strengths and advantages associated with it. This is evident when considering how long it was able to survive – it is still widely used today. The PMR is a familiar concept – everyone is familiar with pen and paper! It is portable (it is as simple as picking up a file and handing it to somebody else), it allows for flexible data recording (the physician can include anything according to his/her personal preferences), it can easily be browsed through or scanned, and is independent from technical requirements and computer "down-time" [Liaw 1993]. Another important advantage is that PMRs do not require special training [Dick 1991].

When considering the alternative data formats included in medical records, the following strengths have been identified [Wyatt 1998]:

- Hand-written prose: Simple and fast to write; flexible, evocative
- Typed prose: Simple and fast to dictate; flexible

- Structured text: Easier to search
- Tables: Compact; easy to search and make comparisons
- Diagrams: Clarify spatial and other relations; unambiguous
- Graphs: Clarify trends.

1.3.2 Shortcomings of the PMR

About a quarter of a century ago, researchers began to draw attention to the shortcomings of the paper medical record. This was mainly due to the poor organisation of documents, incompleteness of information as a result of missing or misplaced files (and the subsequent wasting of time during the search process), inaccuracy, and ambiguity of paper medical records [Van Ginneken 1995]. Other problems associated with the PMR are that physicians and other care providers have to deal with illegible handwriting, and that a paper record can only be in one location at a time. When a record cannot be found at all, an extra temporary record is subsequently created [Barnett 1984; Burnum 1989; Moorman 1994; Wyatt 1994]. This leads to the problem of duplication. Duplication also occurs when double entries are made, necessitated by the need to record the same data many times on different documents [Liaw 1993].

A fundamental limitation of paper-based data is that it can only play a passive role in the decision-making process. Although a considerable amount of information is already available on these hand-written charts, it is not possible to trigger the physician's attention to a patient's allergies, contra-indication for drugs, or abnormal test results. Nor can a paper record actively use treatment guidelines and protocols to comment on its contents. It is virtually impossible, even for an experienced physician, to have all the knowledge relevant to his domain, readily at hand. Retrieval of data from the PMRs is cumbersome, and what is difficult for a human reader to interpret is even less suitable for scientific analysis [Dick 1991; Van Ginneken 1992; McDonald 1984a; Van der Lei 1989].

Neame [1995] gives a detailed description of the shortcomings of paper records by referring to the content and fragmentation thereof:

- Content: Finding and re-using data items
  - Specific items are difficult to find
  - Different users need different kinds and levels of information
  - Information is not collected or is misplaced
  - Once data is committed to the paper record, it is entombed there for ever
  - Costs are high for abstracting data from records.

- Record fragmentation
  - A record can only be in one place at a time and logistical issues make it difficult to move it around as fast as is needed
  - Every health care unit has a separate record for each individual
  - It threatens the freedom of patients to choose where they go for care.

Wyatt and Wright [1998] add the following shortcomings (difficulties) to those already mentioned:

- A huge quantity and variety of data are recorded
- There is rarely an index because it takes too much effort to maintain
- There is rarely an agreed order, structure, or layout, even within an institution
- There are parallel data sources within the record, e.g. progress notes, laboratory reports, correspondence
- Records are commonly disordered because no-one is responsible for keeping them in order
- The paper record is a legal document, so items cannot be annotated, reordered, or deleted
- It is hard to tell whether data items are temporarily missing, misfiled, or will never be available

- Comparison of data is hard: data is spread across pages or record sections; data is recorded in different formats such as words as numbers; most records contain a few tables
- Determination of the context of data is hard: the significance of clinical findings may be recognised too late for other relevant data items to be recorded; the date of recording and other factors critical to interpretation may be unclear
- Identification of trends is hard; there are few graphs; translation of dates into intervals is difficult
- Many records contain distractions, e.g. inappropriate and inconsistent use of colours, logos, and fonts.

In section 1.3.1 the strengths of alternative data formats were highlighted. Similarly the shortcomings of these data formats include [Wyatt 1998]:

- Hand-written prose: Hard to read and search; bulky, unstructured, ambiguous
- Typed prose: Hard to transcribe and search; bulky, unstructured
- Structured text: More difficult to write or dictate; less flexible
- Tables: Hard to lay out; inflexible
- Diagrams: Hard to draw well; take up space
- Graphs: Hard to design and produce well; take up space.

A distinguished American physician has commented: "The (paper) medical record is an abomination ... it is a disgrace to the profession that created it. More often than not the chart is thick, tattered, disorganised, and illegible; progress notes, consultant's notes, radiology reports, and nurses notes are all co-mingled in accession sequence. The charts confuse rather than enlighten; they provide a forbidding challenge to anyone who tries to understand what is happening to a patient" [Bleich 1993:70].

The rapid increase in medical knowledge and technology has led to a large diversity in specialities. Although Plummer [Kurland 1981] introduced the patient-centred record, the

multi-disciplinary aspect of health care caused the logistic aspect of one PMR per patient to become unacceptable. Although records are no longer physician-centred, there are often as many records as there are specialities involved in the patient's care. As a result, the scattering of patient data impedes the formation of a complete picture of the patient. Due to the need to share patient data among care providers, the strategy of brief notes to trigger the memory, no longer suffices [Van Ginneken 1995].

Despite the above-mentioned shortcomings of the PMR, insufficient understanding of the importance of the strengths of the PMR proved to be a great barrier to the introduction of its intended successor: the electronic patient record.

1.4 The electronic patient record

As mentioned before, the need for improving the management of medical information is now critical as a result of the explosion of medical information, and also as a result of the need to provide extensive documentation of patient care to the ever-increasing list of interested parties [Dick 1991; Barnett 1993]. This realisation has lead to the development of Medical Informatics, which can be defined as "the development, use, and evaluation of information technology in health care" [Hersch 1995] (note that this is only one of many existing definitions that have been formulated). Technological progress in the form of the tremendous potential of computer technology has led to great enthusiasm for, and high expectations of applying computer technology to health care [Van Ginneken 1995]. Personal computers are falling in price while there is a continuous advance in speed and storage capacity. Hospitals and general practices are becoming more complex, and the computerisation of many administrative processes is vital for strategic planning and resource management [Kalra 1994].

Modern systems have networks with a central information store and intelligent personal computers on the user's desks. Window interfaces for clinical data entry, using a keyboard, mouse, touch screen with pen, or – further into the future – voice input, can

now become a reality. In future, radio modems will be available for medical practitioners to use on home visits to manipulate data at the central computer database. Sharing information between clinical departments, disciplines, and managers is increasingly important in caring for patients' health problems [Kalra 1994]. One of the challenges is improving the supply lines that take information in a usable form to the bedside, the surgery, the purchaser, or the teaching session [Tonks 1996].

As mentioned before, Weed [1964] has been the first to define the problems that arise with unstructured paper medical records. He has also been among the leaders in trying to computerise the medical record. His first attempt, PROMIS [Weed 1969], may be viewed as one of the classic failures in medical informatics. The PROMIS system soon revealed that solving the memory problem of the human uncovers a *processing limitation* that is even worse than the memory limitation [Weed 1991]. Weed's second attempt to computerise the POMR, the Problem-Knowledge Coupling (PKC) system [Weed 1991], also struggled to survive commercially.

In the previous section the weaknesses and shortcomings of the PMR were discussed. The foundation of health information cannot be accomplished by simply automating the existing paper medical record or by creating massive databases. A fundamental change in information gathering, use, and access is necessary. This change is embodied in the concept of the electronic patient record [CPRI 1996b]. An alternative term that is sometimes used, is "computer-based patient record" (CPR). It is important to note that the term refers to a *computer-based* and not *computerised* patient record. This reinstates the above-mentioned fact that true EPRs are more than automated versions of current paper patient records [Detmer 1995]. The term "electronic patient record" also implies that the record is focused on, and integrated around the patient. The EPR is a complex multi-media record. The ultimate goal is that it will consist of all the clinical information regarding a single patient throughout his/her whole life. This will constitute a true life-long EPR [Andreu 1995].

According to Andreu and Dick [1995], the purpose of EPR technology is threefold, namely to:

- Improve access to patient data
- Improve quality of health services
- Reduce costs.

They continue to state that it is necessary to establish an "information platform" upon which the EPR can be built. This information platform consists of two terms, namely *infrastructure* and *infostructure.* In the context of medical information systems, these two terms have vastly different meanings.

Infrastructure refers to computer hardware, application software, operating systems, programming languages, graphical user interfaces, networks, communication protocols, and related technological issues. The infrastructure must be in place before an EPR can be considered [Andreu 1995].

Infostructure refers to data dictionaries, various coding structures, vocabularies, treatment protocols and guidelines, medical/health care metaphors, and the individual health care practitioner's perspective. This perspective implies the various things a health care practitioner needs in order to use the system to provide cost-effective, quality, and timely patient care. The system must use the vocabulary of the health care practitioner and provide that perspective for looking at problems and patient information. While most information system professionals can easily describe infrastructure, it is not the case with infostructure: many concepts are vague, and the vocabulary to describe the infostructure is lacking. Health care professionals must assume total responsibility for the development of this infostructure [Andreu 1995].

A different view on the EPR is encompassed in the British National Health Service's strategy to introduce the EPR in general practice (and in hospitals). This strategy includes the following classification of levels of the EPR [NHS 1998]:

- **Level 1: Clinical administrative data** – patient administration and independent departmental systems
- **Level 2: Integrated clinical diagnosis and treatment support** – integrated master patient index, departmental systems
- **Level 3: Clinical activity support** – electronic clinical orders, results reporting, prescribing, multi-professional care pathways
- **Level 4: Clinical knowledge and decision support** – electronic access to knowledge bases, embedded guidelines, rules, electronic alerts, expert system support
- **Level 5: Speciality specific support** – special clinical modules, document imaging
- **Level 6: Advanced multi-media and telematics** – telemedicine, other multi-media applications (e.g. picture archiving and communication systems.

1.4.1 The structure of data in the EPR

One can address the topic of "structure" from many different viewpoints. The first viewpoint is the structure of the EPR as the user perceives it. The second viewpoint is the structure of the underlying database. The type of database technology used is usually influenced by functional requirements, existing infrastructure, available expertise, and cost. The third viewpoint is the structure of the conceptual model behind the EPR application. The conceptual model reflects the thoughts of designers of computer systems on how medical data should be collected and used. This model can determine the functionality of the resulting application for data entry, consultation, and retrieval [Barnett 1984; Frisse 1994].

The early versions of the EPR included categories of patient data that were relatively easy to represent in a structured format, such as laboratory data, discharge diagnosis, and medications.

One of the main advantages of structured data is that data can be presented in different views and formats, thereby eliminating the need for redundancy. According to McDonald and Tierney [1988b] and Nowlan [1993], data should be structured and stored in "understandable" chunks. These chunks will facilitate easy browsing of data, the presentation of data in various views, and automated decision support in applications.

1.4.2 The categories of data in the EPR

There are certain categories of data that generally occur in every patient record, namely demographics, a problem list, signs and symptoms, current medications, test results, assessment, and plan [Barnett 1984; Stead 1983; Panzer 1988]. The presence of these data categories is most variable in PMRs, as these permit individual physicians to organise them. EPRs result in more uniform patient records. Partitioning data in categories creates structure in patient records at a macro level. The micro level comprises the data within the categories, such as the actual complaints and findings.

A common denominator of categories is that they are related to the procedure with which the data was obtained. The mentioned categories are in fact source-oriented views on the patient record. In contrast, in a problem-oriented view, data will be related to a problem or diagnoses across the boundaries of the various sources. Both views are important to the physician, but the fundamental difference between the two is that the source-oriented view is data independent, while the problem-oriented view is not. Problem-oriented views can only be supported once the physician has made the necessary semantic relationships between data explicit. Source-oriented views can be supported as a general structure in a patient record [Van Ginneken 1995].

1.4.3 Contents of an EPR

Taking the above-mentioned into account, the Institute of Medicine (IOM) Report published in the United States of America (USA) [IOM 1991] in 1991 suggested that, regarding the content thereof, comprehensive EPRs and EPR systems should:

- Include a problem list
- Support systematic measurement of health status and functional level
- Document the clinical rationale for patient care decisions
- Link to other clinical records across settings and across time to provide a longitudinal record
- Provide comprehensive confidentiality safeguards
- Offer easy access to authorised users
- Allow selective retrieval and formatting of information
- Link to local and remote knowledge, literature, bibliographic, or administrative databases and systems
- Assist in the clinical problem solving process
- Support structured data collection and store data using a defined vocabulary as well as support direct data entry by practitioners
- Aid in the management and evaluation of quality and costs of care
- Be flexible and expandable.

In a list of functions that might be incorporated in an EPR, Logan and Blackman [1999] add a medication list, an allergy list, family history, social history, referrals, order entry and reporting, a printing/fax facility, billing/management, and scheduling to the list above.

It should, however, be born in mind that it will be virtually impossible to find a single system to meet all of the above-mentioned requirements.

1.4.4 Requirements for an EPR

Before discussing the requirements of an EPR, important insight may be gained by considering what is known about physicians' information requirements.

Smith [1996] lists the following requirements:

- Information requirements do arise regularly when physicians see patients.
- These questions are most likely to be about treatment and many of these are likely to be about drugs.
- The questions are often complex and multidimensional.
- The need for information is often much more than a question about medical knowledge. Physicians are looking for guidance, psychological support, affirmation, commiseration, sympathy, judgement, and feedback.
- Most of the questions generated in consultations go unanswered. Without doubt answers to these questions would lead to better patient outcomes or better physicians.
- Physicians are most likely to seek answers to their questions from other physicians, presumably because it is a quick, cheap, and easy method, and because physicians can provide the psychological benefits that is not available from books, journals or computers.
- Most of the questions generated by physicians can be answered, usually from electronic sources, but it is time-consuming and expensive to do so and may demand information skills that the physicians do not have.
- Physicians in developed countries seem to be overwhelmed by the information provided for them. The amount of information is enormous and disorganised, and it is hard to find the answers to questions that arise during consultations.

The answer to providing for physicians' information requirements can be considered using a formula described by Shaughnessy *et al.* [1994]:

$$\text{Usefulness of medical information} = \frac{\text{Relevance} \times \text{Validity}}{\text{Work to access}}$$

In the above formula, the relevance of information is based on the frequency of exposure to the problem being addressed, and the type of evidence being presented. Validity is the likelihood of the information being true, and the work to access the information is the time and effort that must be spent extracting the information. The ideal information source will be directly relevant, contain valid information, and be accessed with a minimal amount of work.

Much has been written on what the ideal EPR should look like. Olsen [1995] stated that electronic patient records should handle multimedia data, it should have coherent links between all the data elements, and that the data should be accessed in a natural and convenient way that matches the convenience of paper-based medical records. It is important to achieve greater performance in data capture and retrieval capabilities. Data should be available immediately without any delays. The EPR should also play a major role in the improvement of the quality of data [Detmer 1995].

One of the main conditions for the successful implementation of the EPR is the direct interaction of physicians with the EPR system. Some applications have adopted an intermediary strategy. In this strategy the attending physician uses pre-printed encounter forms to present recent data and for the recording of new data [McDonald 1984b]. Clerical personnel then enter the information into the computer. Part of the data, such as diagnosis, vital signs, and medication, is usually entered in coded format. Apart from free-text descriptions, which still remain uncoded, this methodology is sensitive to transcription errors, misinterpretation, and delay [Van Ginneken 1995]. The physicians also lose a great opportunity to benefit from the system's functions, for example the creation of reminders and alerts. Rigby [1995] added that in order to get general practitioners (GPs) to participate in a research project like establishing an EPR system, a form of reimbursement, however, is needed. It is also very important to give them feedback and to give them a global picture of the research project.

The recording of an abstracted filtered account of a patient's encounter should attempt to reflect the decision-making process and clinical reality as much as possible [Liaw 1993]. The EPR should provide patient data to support health services research and also macro and micro level decisions throughout health care. This support ranges from the development of clinical practice guidelines to the allocation of resources within and among institutions and communities in order to determine high quality, cost-effective providers. This will undoubtedly lead to new functionality in decision support [Detmer 1995].

Liaw [1993] suggested that a patient record should serve to support patient care by facilitating:

- Information collection, management, and sharing
- Effectiveness and outcomes research
- A community health and epidemiology perspective
- Accountability for the costs of health care
- Teaching and continuing medical education
- Conformance to legal and financial requirements.

Neame [1995] elaborated on this by stating that the medical record should:

- Enable physicians to review previous care events, reach timely and appropriate clinical decisions, develop treatment plans
- Provide archival and legally acceptable record of steps that were taken in the care of an individual (when, why, by whom)
- Enable staff to audit care provided to an individual
- Act as source of information which will enable administrative functions to be carried out automatically as a by-product of the clinical data collected
- Be stored so that it is secured from loss, alteration or damage
- Be subject to access controls that ensure patient's privacy.

The medical record of the future will need to provide the clinical practice with a flexible and shareable framework for recording and analysing the consultation process [Kalra 1994].

Another important requirement of an EPR is the representation of time. Since the patient record essentially involves the recording of events over time, the representation of time has been subjected to many studies. Time stamping of patient data is a method used to comply with this requirement and is important for a variety of reasons [Van Ginneken 1995]:

- The physician consulting the record relies on time-stamps to determine whether certain investigations need to be repeated, or whether medication needs to be renewed
- The physician also uses time-stamps to analyse trends and correlations [Powsner 1994].

Depending on the context and purpose for which data is used, time-stamps differ in nature and precision. Time may be expressed as an absolute expression ("5 May 1998, 4.00 p.m."), as a relative expression ("two days later"), or as a duration ("lasted 20 minutes") [Van Ginneken 1995].

Weed [1969] introduced a flow sheet (tabular format) to facilitate the comprehension and interpretation of interrelated and changing variables. In a paper record the data for all retrieval purposes are necessarily in the same form as the entry. Computer-based records, on the other hand, may allow retrieval in many forms. Weed [1991], therefore, states that flow sheets (with almost any number and arrangement of variables) have become an expected feature of any EPR system. The emphasis from the point of view of good care and good education should, however, be on how to choose the correct variables

("Parameters to follow") for the flow sheet and how to interpret the relationships among them.

In the Netherlands, Van der Lei *et al.* [1993] identified four critical areas that determine the success of the EPR. These areas are a standard clinical vocabulary, direct physician interaction with the computer, the role of professional societies, and the role of government funding. The work done in the Netherlands regarding the EPR will be discussed in detail in Chapter 2.

1.4.5 Strengths / Advantages of the EPR

As mentioned before, the potential benefits of the electronic patient record are recognised. The evaluation of systems already in place and the analysis of the concept have led to a variety of positive remarks concerning the EPR.

In a broader sense, computerisation of health information provides many opportunities to improve a nation's health care, as well as reducing costs. Informed decision-making will depend on improved access to the considerable amount of clinical information. Better clinical decisions will improve quality and costs. Clinical information, pooled in regional and national databases, and available via networks, will be an important source of information on which to base national health policies. The availability of this pool of information could be a direct result of having EPR systems in place. It could also have the following advantages, namely [Andreu 1995]:

- The undertaking of clinical studies about effectiveness and applicability
- Acceptable reimbursement policies
- Scientific hypotheses for further research.

The availability of patient data in electronic form already has important advantages compared to the paper predecessor, namely that patient records can be accessed at

multiple locations, patient data no longer needs to be scattered, and the problem of illegible notes is a problem no more [Van Ginneken 1995].

The ability of computers to use single items in multiple ways, is also of great help where the EPR is concerned. Double entry is eliminated, time is saved, and it eliminates the tedium of writing referral letters or laboratory requests and reports. The increasing demands for data by health care team members and requests by patients for access to their records can be met, and it enables quality control efforts to be focused at the single point of data entry [Liaw 1993].

Apart from being advantageous to the physicians and patients, the EPR can also serve the following groups, namely [Andreu 1995]:

- Pharmaceutical manufacturers
- Insurance companies
- Large company employers
- Health care service firms
- Health care consultants
- Health care service researchers.

1.5 Motivation for and purpose of this thesis

Doctors and people in the medical profession are realising that computers can support their clinical practices. Unfortunately the computer technology currently installed in most hospitals and general practices, are ill equipped to cope with the exciting possibilities ahead [Kalra 1994]. Many of the earlier systems found in hospitals and general practices are based on large, intelligent, central computers with simple terminals at user ends. Disillusioned medical practitioners have seen lots of money wasted on useless hardware. Resources were diverted from patient care to administrative information systems, developed by information technologists, for managers (e.g. the Resource Management

Initiative in the UK in the late 1980's [Packwood 1991]). Those interested in Medical Informatics have tried to develop systems that will help doctors in their daily clinical tasks by providing them with information. Very few of these systems have, however, been adopted and most doctors continue to practise without them. Medical Informatics has been dominated by concern with the technology, and not by understanding the needs that technology must meet [Smith 1996]. All this has traditionally alienated medical practitioners from the disciplines of Clinical Information Management and Medical Informatics. There also remains a cultural gap to be bridged before medical practitioners can truly be in control of the way information is collected and used in their workplaces, as it is often found that communication experts use incomprehensible jargon.

The private practice setting, a microcosm of administrative, departmental (investigations, prescribing), epidemiological, and clinical settings, is a logical place to attempt to combine and share information among functions [Liaw 1993]. Medical practitioners maintain medical records for patients to record details of individual contacts, to monitor patients' health status, to monitor the practitioner's health behaviours, and to support legal requirements [Lambert 1993].

Considerable effort is invested in writing, filing, sorting, searching, retrieving, issuing, and recovering the medical record, in whole, or in part. There is no doubt that the availability of well organised, legible, accurate, and comprehensive clinical notes can play a very significant role in the clinical decision making process and assisting in the provision of quality health care [Neame 1995]. Technological progress and increasing acceptance of computers by patients and practitioners increase the likelihood of achieving full-fledged electronic patient records. The Institute of Medicine (IOM) Report published in 1991 in the USA [IOM 1991] concluded that:

- Health care was in desperate need of EPRs
- Despite the status of current systems, technology was not the limiting factor in EPR development

- A concerted effort could make EPRs a reality sooner rather than later.

Yet, twenty-five years after the inception of the EPR concept, there is still no EPR in widespread use that fully replaces the paper chart (with some exceptions for primary care). Apparently, for physicians, the potential benefits of the EPR do not yet outweigh the strengths of the PMR [Van Ginneken 1995].

The results of research done to find the reasons why EPRs are not generally used in physician practices in the USA [IOM 1991; Detmer 1995], identified the following barriers to be bridged:

- The lack of a clear definition of EPRs
- A leadership gap with respect to EPRs
- System cost
- Legal issues and social concerns (i.e. privacy)
- Infrastructural needs.

Andreu and Dick [1995] addressed this issue by listing eight factors that influence the EPR, namely:

- Accelerated advances in technology
- Increasingly powerful and affordable hardware
- Growing emphasis on mobile computerisation
- Reduced cost of magnetic and optic storage
- Improved human-computer interaction
- Growing need for improved documentation in all clinical settings
- Emphasis on the quality of patient care and reduced costs
- Better information for decisions.

They concluded that the EPR has the potential to do for health care what the transistor did for electronics [Andreu 1995].

Taking the aforementioned needs and requirements for a successful EPR into account in this thesis, an attempt will be made to:

- Ascertain whether a need for EPR systems exists among general practitioners in South Africa
- Identify problems associated with current paper medical records used in general practices in South Africa
- Identify the requirements, expectations, and needs regarding EPR systems as seen from the viewpoint of general practitioners in South Africa
- Design and present prototype[1] EPR systems for evaluation and testing by general practitioners in South Africa according to the requirements, expectations, and needs as mentioned above
- Conduct a usability assessment of the above-mentioned prototype EPR systems
- Present the general practitioners of South Africa with a model of a proposed EPR system, designed for their specific requirements, expectations, and needs.

1.6 Structure of the thesis

After the historical perspective on the patient record given in Chapter 1, Chapter 2 investigates the status of the EPR in the rest of the world. This is done by identifying data models, systems developed, and research done. Problems encountered and lessons learned are further identified. The chapter concludes with a look at future developments on the table.

[1] Prototyping is "the building of a subset of an application to assist in requirements definition, to test a proof of concept, or to provide a partial solution to a particular problem." [Conger 1994].

Having discussed the EPR status in the rest of the world, Chapter 3 gives a South African EPR perspective. The manual system used in the majority of South African general practices is explained. Medical computer systems in use, are then addressed.

Chapter 4 is applicable to general practitioners in South Africa. It explains the process that was followed in order to do a requirements analysis among GPs in South Africa. The needs and problems GPs experience, are listed and discussed.

The results of the requirements analysis are used in Chapter 5 to design the first EPR prototype. The prototype is discussed in detail.

Chapter 6 commences with brief background information on the principles of evaluation. This is followed by a discussion on the processes and methods applied to evaluate the first prototype, as well as the results thereof.

Chapter 7 will describe the updated version of the first prototype after the results of the evaluation had been taken into account.

A purchased prototype, namely the HUB Computer Medical System, is discussed in Chapter 8. The system is based on Foresighted Practice Guidelines, a concept that will be explained in Chapter 2.

In Chapter 9 the evaluation of the second prototype (including a comparison between the two prototypes) and the HUB will be discussed.

Chapter 10 presents a recommended model for the development and implementation of an EPR system for general practitioners in South Africa. Chapter 11 presents the conclusions and a brief look at possible future developments.

1.7 Summary

In this chapter the reader was introduced to the problems physicians face as a result of the world-wide information explosion. The patient record was suggested as a first step to order this magnitude of medical facts that are generated inside and outside the consultation room.

The origin and history of the patient record was narrated, followed by a description of current paper medical records (PMRs). This description included the strengths and shortcomings of the PMR. Next the electronic patient record (EPR) was discussed, including sections on the structure and categories of the data in the EPR, the contents, requirements, strengths, and weaknesses of the EPR.

A motivation for and purpose of this thesis was subsequently given. The chapter was concluded with an explanation of the structure of the thesis.

Taking into account the introduction given in Chapter 1, the next chapter will explore what has already been done in the rest of the world regarding most of the major aspects surrounding an EPR.

Chapter 2

The Electronic Patient Record: The Rest of the World

2.1 Introduction

In this chapter an attempt will be made to give an overview of the work already done in the rest of the world regarding the electronic patient record. It must be stressed that the author by no means claims that the examples given constitute a complete list of research studies. Selected studies are presented in order to attempt to cover the major research issues.

The representation of patient data into data models will first be discussed, followed by examples of systems already developed and research done. The problems encountered and lessons learnt from the above-mentioned research studies will then be summarised. The chapter is concluded by giving a brief look into what the future might have in store regarding developments in the field of the EPR.

2.2 Data Models

It has been stated that, among computer analysts, it is known that before one can develop a computer program, one must first have a model [Naegele 1995]. Before discussing the three main data models that were considered in this thesis, namely the Template Model, the Hindsighted Practice Guideline Model, and the Foresighted Practice Guideline Model, a few other existing models will briefly be discussed in the section below.

A straightforward way of representing patient data is a table[2]. This table defines by which attributes a particular entity may be described [Barnett 1984; Kuhn 1984; Stead 1983]. This approach is rigid, the reason being that a change to a table would require adjustments to the application. Another reason for the rigidness is that when certain attributes can be used in more than one context, redundancy may be the result. Tables function well if the data set is stable and can meet with the consensus of its users. The more the users differ in their needs, the more difficult it will be to reach this consensus.

In search of larger flexibility, other strategies have been applied for the structured representation of patient data. One of these strategies involves a knowledge model. This model consists of a predefined vocabulary and of knowledge about how the terms of this vocabulary may be combined into meaningful expressions. The instantiations of that knowledge constitute the actual patient data. In order to gain a better understanding of this model, it is important to note that the data is often represented in triplets [Rector 1989]. The basic structure of a triplet is "object-attribute-value", for example "diabetes-control-poor", or "pain-location-leg". Terms are often ordered in a hierarchical structure, in such a way that a "child " in this structure inherits its parent's relations. A relation may therefore only be defined when it applies to all children of the parent in question. The entity-attribute-value (EAV) representation is a means of organising highly heterogeneous data using a relatively simple physical database schema, namely a column for entity/object identification (ID), one for attribute/parameter (or an attribute ID pointing to an attribute description table), and one for the value of the attribute. EAV/CR is an enhancement to the EAV representation to handle the modelling of complex objects (classes), as well as to manage inter-object relationships [Nadkarni 1999].

Facilitating browsing through patient data leads to another strategy for structuring patient records. Essin's dynamic data model [Essin 1993] is one example. The basic elements of the database are items that appear on documents. These elements can be combined to

[2] A table (also called a relation) is a matrix consisting of a series of row/column intersections [Rob 1997].

define any type of document. Although this model is very flexible and provides easy access to data, analysis of data requirements require a detailed semantic model of the documents involved [Van Ginneken 1993].

Hypertext, or Hypercard, both use a variation of the browsing approach [Conklin 1987; Bluemke 1993]. Related Hypertext documents are linked together. A highlighted area in a document indicates the presence of a related document and can be used to access it. This strategy offers no potential for the generation of different views on the data, nor for data analysis, unless a semantic model exists that defines a mapping to a database.

Presently the three most familiar basic models that have been developed for computer-based patient records are the Template Model, the Hindsighted Practice Guideline Model, and the Foresighted Practice Guideline Model [Naegele 1995]. These three models will now be discussed.

2.2.1 Template Model

The word processor model, more commonly known as the template model, is by far the most popular, with more than 95% of the available products using this model. According to Naegele [1995], this is one of the unfortunate reasons why computer-based medical records are not being used by the majority of physicians. Patients are individual and unique, therefore medical notes about patients also tend to be unique.

Naegele [1995] continues that the main problem with the template model is that the notes generated are too similar. Inaccurate patient notes, generated using a template model, have often been found in medical records. Other problems encountered with the template model include high training time (from 16–200 hours per end user), high customisation time (100–1000 hours), and the need for typing skills. Users also complain that, at demonstration time, the screens and functionality of the EPR system looked excellent. When put into practice in the physician's office, the program could, however, simply not do the job.

2.2.2 Hindsighted Practice Guideline Model

Before discussing two specific types of guidelines in the following two sections, a better understanding of what a guideline constitutes, is necessary. According to the Institute of Medicine [Field 1990]: "Guidelines are systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances". Medical practice guidelines are the databases of the science of medical decision making and disposition processing. Under scrutiny are the only two basic approaches to the science and definition of clinical practical guidelines, namely hindsighted and foresighted [Naegele 1993].

The Hindsighted Practice Guideline Model (HPG), also known as the retrospective clinical practice guideline, has been described [Naegele 1995] as a "cookbook" concept. It is diagnosis or procedure oriented. It starts with a conclusion, such as a diagnosis or surgical procedure, and works backward to determine whether the conclusion is justified by the history, physical examination, and test data. The physician chooses a canned report by the name of the diagnosis reached or procedure to be performed. He/she can then edit the note using word processor skills.

HPGs are sometimes useful in quality assurance, utilisation review, and studies by peer review organisations. A variety of problems are, however, associated with HPGs. According to Naegele [1995], every HPG has a specific therapy for a given diagnosis that is usually related to a literature review, and not what is occurring as the standard of care. He continues that "HPGs have been very helpful for the plaintiff's attorney for malpractice". This style of auditing is a form of second-guessing and has often led to friction between practitioners and their auditors. Another problem mentioned, is the time required to edit the canned note in order to make it unique for a particular patient. The editing can take up as much time as the encounter, making it very difficult for physicians to use.

The philosopher Soren Kierkegaard said: "Life can only be understood backward, but it must be lived forward". Naegele [1995] states that this quote can be applied to medicine as well: physicians cannot benefit from HPGs, because they do not know the conclusion until they have interviewed and examined the patient. A possible solution to the mentioned problems is Foresighted Practice Guidelines (FPGs).

2.2.3 Foresighted Practice Guideline Model

The FPG model was observed in the Medical Industry Study. The process-flow of all physician activities, including all the interactions with patients and staff, as well as disposition processing, was diagrammed at seventy health care facilities of most types, in eight States of the USA and in the Philippines [Naegele 1993; Furry 1988].

This study revealed that physicians use a top-down problem solving method to determine the most likely diagnosis and the best therapy. Using this prospective approach, physicians mentally traverse a list of lists, or a series of check lists to understand the patient's problem(s), make decisions and recommendations, and create the medical note [Naegele 1993; Furry 1988].

The FPG model is problem or medical systems oriented. In decision science terms, the FPG model is an algorithmic set of decision tables placed in the order in which the steps of the physician-patient encounter occur. This is called Process Flow Management [Goldratt 1989]. Physicians use the decision table model to collect and evaluate data in a problem or systems oriented manner to come to a logical conclusion. By using FPGs, physicians can therefore document patient encounters and simultaneously collect data needed for outcomes assessment.

The FPG model starts at the beginning of the physician-patient interaction. It is a data structure[3] where the entire interaction, the process flow, the supplies and inventories, all

[3] A data structure is simply a way of organising data [Naegele 1996a] .

of the possible diagnoses, procedures, forms, therapies, patient education, and interactions are included. According to Neagele [1995] it is the only all-inclusive model and, although debatable, the only object-oriented model.

As opposed to working backwards from a conclusion to see if the appropriate data exists, (as is done with the HPG model) the FPG model uses data to reach conclusions [Naegele 1996a] . Furthermore, this model is a create-a-note style, rather than a template style [Naegele 1995].

Managed care physicians have two main sets of databases, namely the patient files and the data used to create the patient files. As a computer program needs a data model, a data model in turn needs a data structure before the model can be designed. Presently there is only one formal database structure for the database information used to create the patient files. This data structure is called the Standard Practice Guideline Format (SPGF). The SPGF is a data structure that allows the managed care firm to define their database using process flow management techniques. The physicians use the information in this database to interact with the patient and all of the other role-players for every patient interaction. One of the purposes of the SPGF is to give managed care groups the ability to compete by providing information on quality, cost, supplies, and outcomes as measurable variables [Naegele 1995].

The other database is the patient records. Although the specific data (words and phrases) within the decision tables in this database may differ from physician to physician, the data structure is the same. This universal data structure is called the Standard Patient File Format (SPFF).

Presently there are fairly adequate sets of FPGs for Family Practice, Internal Medicine, Orthopaedics, and Emergency Medicine/Urgent Care. These are being used at point of care with hand held and desktop computer technology. Considerable advantages have been reported, for example cutting operational costs, increased physician efficiency, and

increased quality of medical care. FPGs have also helped the physician during audits and during malpractice suites. Additionally, because of the fact that FPGs are said to define most fields of medicine, it has been stated that the art of medicine will be preserved with the use and building of the guidelines for efficiency and quality of care. With a complete (or as close to complete as possible!) set of guidelines, physicians will be able to improve their skills, as the guidelines will assist them and continually educate them. Therefore it has also been stated that the FPG can take medicine and move it to a real science – a concept people have been trying to achieve for centuries [Naegele 1996a].

2.3 Systems already developed / Research already done

In this section a few selected examples of research work done on the EPR in different countries in the rest of the world will be discussed. Where the information could be obtained an indication will be given of the type of user interface (graphical or character-based) applied to each system.

2.3.1 Belgium

2.3.1.1 HEALTH *one*

A state-of-the-art example of an EPR is HEALTH *one*, a Belgian product built on the fundamental concept that a patient record must be completely adaptable to the individual's case, in terms of content and structure [Health *one*].

In Health *one*, the data structure, the functions and the user interface have been developed in an innovative way. The data structure consists of language independent portable files, composed of detailed data-elements that are assembled in a highly flexible, but standard way. The data entry and analysis functions are powerful, and are created specifically for the medical environment. The user interface can be configured to the needs of individual users or groups. As a result, Health *one* can be customised into specialised products, for example a GP or a hospital configuration.

Health *one*'s functionality includes [Health *one*]:

- Drug prescription
- Automatic integration of laboratory and radiology protocols
- Integration of text and medical imaging
- Quick search and retrieval of healthcare records
- Analysis of one healthcare record or a set of records
- Writing and printing of documents, reports and certificates
- Displaying numeric data in a chart or pictorial format
- Exporting and importing healthcare records.

The system has a visually appealing, graphical-based Windows user interface.

Health *one* is designed to be not only a computerised healthcare record *filing* system, but also an electronic healthcare record *management* tool [Health *one*].

2.3.2 Canada

2.3.2.1 FAMUS Project

FAMUS (for Family Medicine, University of Sherbrooke) is a computer network developed for use in primary care throughout the province of Quebec, Canada. It was conceived in 1990 for the purpose of creating a primary care risk register – a large meaningful sample of clinical data, initially on the risk of cardiovascular disease [Grant 1995].

Grant *et al.* [1995] stated that two of the most important objectives of the FAMUS project were to:

- Make the system both useful and easy to use

- Study the factors that might increase the physicians' willingness to use the computer themselves.

The reasons for the above-mentioned objectives were that, although it might be assumed that a network system will be of interest to a primary care physician, he/she might not be willing to add computer-related tasks to an already full program. Additionally, the physician might be interested in primary care research in principle. If the tool is not compatible with his/her other tasks, the desire to participate in such a project can be expected to fade rapidly [Grant 1995].

The faculty ethics committee of the University of Sherbrooke gave the following instructions / guidelines regarding the FAMUS project [Grant 1995]:

- Patient identifiers were not permitted to be transmitted (it was originally requested to allow eventual correlation with other databases used to monitor health status)
- The introduction of the computer into the physician's office should not interfere with normal practice
- Written patient consent for the use of the system was not required – information concerning the project had to be displayed as a poster at the physical point of care
- Data encryption was not used, but passwords were used on all computers
- Data compression was used to reduce telecommunication costs.

In the FAMUS project patient data is entered at each successive visit to a doctor. The data, therefore, serves to record patient outcomes and link them with medical decisions. The quality of data was monitored at three levels, namely at the moment of data input, on receipt of the communication data, and by an automatic surveillance process [Grant 1995].

It has been suggested that the greatest barrier to the successful operation of an EPR is the apparent inability to devise a means of accurate, efficient, and economical data entry [Rodnick 1990]. In practical terms this means that the number of keystrokes necessary for

data entry, at any given visit, must be kept to a minimum. Errors in data entry must also be easily identified and corrected. Most importantly, the system must be reliable, meaning that it must be fully operational whenever the physician wishes to use it [Stead 1989]. The experience with FAMUS confirmed the above observations, especially the need to minimise the task of data entry. According to Grant *et al.* [1995], many characteristics of general practitioners in terms of patient care are similar, despite variation in the organisation of the health care system. The FAMUS project did not provide for a complete medical record to the participants, but the findings were compatible with other work on the introduction of EPRs.

2.3.3 Israel

2.3.3.1 CLINIC

The computerised medical record program, CLINIC, was specifically designed at the Faculty of Health Sciences, Ben-Gurion University of the Negev, Israel. It was to be used on-line in a primary care clinic, during a patient encounter, by healthcare professionals [Warshawsky 1994]. CLINIC is organised according to the Problem Oriented Record [Weed 1968], and the medical content is structured according to categories of problems and diseases that have common signs and symptoms.

Prior to computerisation of the medical record, medical data was kept as hand-written records in folders. These folders had to be extracted by a nurse or medical secretary, or even sometimes by the physician. It was then brought to the physician's office, and subsequently refiled [Warshawsky 1994].

With CLINIC, the physician uses the computer on-line to review the patient record, as well as document the encounter and issue relevant forms. This implies that, during a routine visit, the physician, seated at a desk, greets and identifies the patient. He/she establishes the reason for the visit, reviews the record, and records subjective data. The physician then examines the patient on the examining table, ultimately returning to the desk to complete the encounter with instructions, discussion, and the recording of

objective data and plans. Relevant forms, such as referrals, prescriptions, and test orders are also issued [Warshawsky 1994].

Warshawsky *et al.* [1994] states that there are serious problems associated with data entry by an intermediary from physician prepared encounter sheets, oral recordings, or extraction from the conventional hand-written record. The illegibility of both the coded forms and written patient records lead to data entry errors. There is a substantial time lapse between the patient encounter and data entry. Other problems are the inaccessibility of the complete patient record at the time of the physician/patient contact, and the additional cost of data entry clerks. Warshawsky *et al.* [1994] continues that the ideal would be that the primary user of the record should enter data at the data source (place of medical care), that data should only be entered once, and that data should be more accessible to all parts of the computerised medical record system.

Opinions vary regarding the practical implications and acceptability of data entry by the medical practitioner during the patient encounter. The following questions need to be addressed [Warshawsky 1994]:

- Will the practitioner use the computer?
- Will this computer-use influence the way in which he/she interacts with the patient?
- Will the computer change the work style of the physician?
- Will the on-line use of a computer change the length of time needed for chart review, documentation, or the entire encounter time?

According to Warshawsky *et al.* [1994], the findings of the analysis of the effectiveness and use of CLINIC indicated the following:

- The review of records took up less time with the use of the CLINIC system. This was the result of the accessibility and retrievability of patient records due to the organisation of the computer record.

- Documentation time increased: more information was recorded, and the type of data that was recorded, changed. The coded help menus served as reminders for more detailed encounter documentation.
- A reduction in interaction time with the patient occurred as a result of a change in work style. When using the computer, the physicians tended to work in the blocked pattern, first establishing a number of items of information and then entering the data into the computer. During this period of data entry, physicians devoted minimal attention to the patient – no eye contact or conversation – while concentrating fully on the computer.

2.3.4 The Netherlands

2.3.4.1 Elias

The Netherlands has come a long way in using computers in medical practices with the Elias system. Before discussing the system itself, a brief explanation of the Dutch Health Care System may be appropriate.

In 1991 there were 6400 general practitioners in the Netherlands. The average size of a general practice was 2350 patients. Nearly every Dutch citizen is enrolled in the practice of a general practitioner. A general practitioner will, on average, see 35 to 45 patients a day. Sixty percent of all patients are insured through medical funds (compulsory insurance for any one with an income less than $30000). Patients are free to change from one general practitioner to another, but it rarely happens. When a patient transfers, so does the patient record. Patients generally contact their general practitioner, who might refer them to a specialist, if appropriate. General practitioners are also reimbursed a flat fee per year per medical fund patient [Van der Lei 1993].

In the Netherlands physicians can choose among several competing information systems that are based on the requirements formulated by professional organisations of general practitioners. Information systems used by general practitioners consist of different interrelated, dependant modules. These modules can share data. The general practitioner

is, however, free to decide which modules of an information system to install. Installation of modules of an information system occurs stepwise, beginning with administration and financial modules, and ending with the computer-based medical record. The time lapse between the first and last step is at least one year.

All available information systems provide the same basic functions, and therefore the replacement of the paper record with a computer-based record is allowed. Additionally, they support a problem-oriented medical record. None allow for storage of non-textual data such as images. The requirements formulated by professional organisations are based on the principle that physicians themselves must use the electronic patient record during consultation to inspect and record clinical data. The systems do not support initial recording of data by the physician on paper, which is then followed by transcription of the physician's notes by clerical personnel. The systems also do not print paper forms [Van der Lei 1993].

Elias was one of the systems that pioneered electronic patient records in general practice. It was written in M language for a PC386 with MS-DOS. In the Netherlands the National Board of Public Health adopted Edifact as standard for electronic data interchange between systems used in health care. Elias allows for communication with information systems outside the practice. The most common connections are GPs with pharmacies, laboratories, and hospitals. General practitioners communicate amongst one another via electronic mail. Electronic mail allows free text and coded data [Van der Lei 1993].

Elias consists of five modules, namely the basic, financial, pharmacy, patient record, and communication models [Van der Lei 1993]. Considering the patient record specifically, it replaces the paper patient record, except for non-textual data such as images. The general practitioners use the patient record to retrieve, review, and record data during the consultation. The physician must code the patient data, for example the types of visits or procedures, the prescribed drugs, and doses. The system has a character-based user interface. For the overall structure, Elias supports Weed's model (see Chapter 1) and the

problem-oriented patient record. A database of all drugs available in the Netherlands, maintained by the Royal Dutch Association for the Advancement of Pharmacy, enables the physician to code prescriptions. If codes are not used, Elias assumes free text and behaves like a word processor. Elias displays selected parts of the patient record in alternative modes, for example textual or graphical. Non-consultation data, for example laboratory data or data received from specialists, are entered by clerical personnel. When the electronic patient record is introduced into a practice, clerical personnel enter summaries of existing paper-based patient records before they are archived [Van der Lei 1993].

According to Van der Lei *et al.* [1993], possible reasons for the rapid growth in use of the electronic patient record in the Netherlands in comparison with the United States and South Africa are:

- **The nature of general practices in the Netherlands** – The Dutch professional organisations declared that the role of the GP in the health care system is to provide population-based services responsive to both individual and collective needs. The patient records must, therefore, be able to provide and co-ordinate care for the individual patient and support population-based services. Conventional paper-based patient records are unable to provide such a population-based service. The addition of electronic communication provides added support to GPs in decreasing their work load and increasing their knowledge of care delivered by other health care providers.

- **The role of professional organisations** – Professional organisations were early and active participators in recognising the potential of computer-stored patient records. This was done by issuing guidelines for information systems in general practice and revising and publishing them regularly, evaluating available systems, and providing post-graduate training that prepares physicians to use these systems. An important issue in the introduction of information technology is the expectations

of the users. If it is too high, the users become disillusioned. On the other hand, if it is too low, the introduction of technology is impeded.

- **The existence of government incentives promoting the use of computer-based patient records** – The government reimburse general practitioners for 60% of the expenses incurred, related to the introduction of computer-based patient records with a specified annual maximum amount. To qualify the GP must use a system that passed evaluation by the professional organisations, introduce computer-based patient records within two years and provide data for health policy planning.

2.3.5 The United Kingdom

The primary health care sector in the United Kingdom has been transformed in the years since 1986 by a series of legislative changes. The medical care is provided by GPs. The above-mentioned changes had profound implications for the information requirements of the GPs. It has led to wide-spread adoption of computerised patient record systems by them [Gillies 1995]. Hayes [1985], however, identified the following barriers to the adoption of computers before the new legislation came into place:

- Incomplete coverage of all activities
- Fears about confidentiality
- High mean age of GPs (more than 60% were over the age of forty).

These results may be compared to a survey of GPs using computers done by Shum [1992] after the new legislation:

- 60% found selected systems a problem
- 49% experienced difficulties using their systems
- 70% wanted to learn more but didn't have enough time.

Shum [1992] also found that the usage of installed systems was well below the maximum potential levels. In addition to the lack of practitioners' knowledge about their systems, other reasons for this state of affairs were problems in coding diagnoses and major cultural problems in practices where partners had often split into "pro"- and "anti"-computer camps. This created a cultural hurdle, because many practitioners were not used to working together and effectively compromising their clinical judgements in order to reach consensus. Another very serious situation occurred where a system was in use and apparently functioned correctly, but doctors and practice staff had insufficient knowledge to recognise a major potential lack of data integrity.

Sullivan and Mitchell [1995] conducted a review that concentrated on the effects of desktop computers on consultations, and on patient care in particular. A world-wide review of published work was conducted. Prospective studies were selected if:

- They concerned doctors or nurses in a primary care setting
- They described any computing system designed for use by a doctor, either in routine clinical practice or for a specific research project.

The systematic review of published work yielded only thirty papers evaluating the effect of computers on the consultation process, clinical performance, and patient outcomes. The key results indicated that:

- Fifty five per cent of general practitioners in Britain use desktop computers to access clinical data during consultations
- Using a computer during a consultation lengthens the consultation time by 48-90 seconds
- Use of a computer during consultations improves immunisation rates by 8-18% and other preventive tasks by up to 50%
- Using a computer during consultations does not seem to have appreciable impact on patient satisfaction

- More work is needed to assess the effects of primary care computing on patient outcomes.

There is evidence that the introduction of computers to the United Kingdom in a revolutionary way, in different types of organisations, is not the best way to achieve maximum benefit [Baugh 1993; Gillies 1994]. If one considers implementation as a process somewhere between the ideal case of gradual change and the "big bang" approach, then one can see that it is possible to implement a computer system in an evolutionary way. The principle advantages of an evolutionary approach are a recognition of the need for planning and the opportunity to assimilate change in small doses [Gillies 1995].

According to Gillies [1995] a basic process of evolutionary change for GPs from a paper-based to a computer-based system might be considered in terms of the following stages:

- Make the paper system computer ready
- Implement a common diagnostic coding policy within the practice
- Implement and evaluate pilot single-user systems by computerising only those functions that bring maximum benefits at minimum cost
- Expand the scope of a single-user system to include all major functions
- Implement a multi-user system putting terminals on the physicians' desks.

All practices will benefit from the use of a single-user system as a pilot implementation. The advantages are a reduction in the initial problems of computerisation to more manageable proportions, it allows diagnostic coding practice to be established and, if restricted initially to certain areas, it can provide rapid benefits at limited cost. It also allows the more sceptic members of that practice to be convinced before embarking upon wholesale change [Gillies 1995].

Some practices, however, never progress beyond this point. This can be attributed to the fact that a multi-user system may not be necessary in small practices. Computerising patient records beyond limited areas may be expensive, time-consuming, and unjustified by benefits. The practice may not be able to afford the extra technical expertise to run a multi-user system. The practice may regard the presence of a computer terminal in a consulting room as an unwarranted intrusion upon doctor-patient consultations. A limited solution that works well may be more effective than a more ambitious solution that fails [Gillies 1995].

An additional important issue noted, regarding the implementation of computers in general practice, is patient confidentiality. It is essential that computerisation does not compromise standards through ignorance. Poor initial training, poor documentation, and lack of time and support for ongoing development of skills are other issues that could be barriers to greater computer-use in general practices [Gillies 1995].

The EPR forms an integral part of the British NHS strategy [NHS 1998]. This strategy's proposed levels for developing an EPR were presented in section 1.4. Additionally, publications on Informatics evaluations in primary care are contained in the DIEP (Database for Informatics Evaluations in Primary Care) database [DIEP 1999]. The creation of the National electronic Library for Health (NeLH) may be viewed as an attempt to harness internet technologies to solve the information paradox – where modern healthcare professionals are overwhelmed with information but cannot find particular information when and where they need it [Gray 1999].

2.3.5.1 EMIS

Pringle *et al.* [1995] undertook a study to access the completeness and accuracy of EMIS, a computer medical record system. Four general practices in the Trent Region in the United Kingdom, that were known to be high recorders of clinical data on the EMIS system, were selected.

The reason for this study can be explained in the following manner: if the data from general practice computer systems are to be of value to the practices, and, in aggregated form, to the health service, they must be complete and accurate. According to Pringle *et al.* [1995], the results of the study were cautiously encouraging. In all four practices the computer recording of ten major diagnoses appeared to be sufficiently complete and accurate to be of value.

The comparison of the manual records with the computer records in the four practices suggested that, for the main items of interest in data aggregation, namely diagnoses, prescriptions, and referrals, the computer files were either more accurate than or were comparable to the manual records. These records did, however, not reflect the rich detail of the consultations as recorded in traditional manual records, as it was clear that the practices were selecting areas that they considered important to record on their computer systems [Pringle 1995].

2.3.6 The USA

Barnett *et al.* [1993] stated in an article that the majority of computer-supported medical information systems in the United States at that stage, had their primary emphasis on support for financial, administrative, and communication functions, and not on the clinical record. Some systems have incorporated the retrieval of previously transcribed clinical data, such as radiology reports and problem notes. The data could then be viewed simultaneously by multiple persons at different sites. In these systems the patient information is accessed either through direct inquiry at a computer terminal or through computer-generated summaries and reports.

Examples of systems that are in place in the USA will now be discussed.

2.3.6.1 EpicCare

In May 1993 CIGNA Healthcare of Arizona implemented a comprehensive automated medical record system in a pilot project performed at a primary care clinic in Chandler,

Arizona. The system, EpicCare, operates in a client-server environment. It is a Windows application with a graphical user interface, and completely replaces the paper chart in all phases of medical care [Churgin 1994].

In order to give an indication of the scope of the system, the main menu bar offers a choice of the following functions: Patient, Schedule, Exam, Review, Charting, Other Encounters, In Basket, Desk, Message, Pathways, Secure, and Help [Churgin 1994].

Positive user response about the system included that the screens assisted patients to gain a better understanding of their clinical status. Office personnel commented that the in and out procedures had improved, that redundant paper work had been reduced, and that communications between nurses, physicians, and administration personnel had improved. The patients accepted the system and encouraged them to proceed with the good work [Churgin 1994].

On the negative side it was found that the physician's personal style was less spontaneous with the computer, and that the physicians felt intimidated by using the computer in the presence of the patient [Churgin 1994].

According to Churgin [1994] the main difficulties experienced with the project were:

- Problems with the laboratory and transcription interfaces, leading to a loss of information
- Difficulties with downloading existing data on patients' demographic features and insurance benefits, causing inaccuracies and extra work for the front office staff
- Problems with getting incoming information, such as off-site or hand-written reports, to interface with the system
- Early problems with the hardware and network, causing system failure unrelated to the application itself

- Difficulties with the vocabularies used in the International Classification of Diseases (ICD-9CM) and Current Procedural Terminology Databases
- Problems with conversion of existing paper-based chart data to the computerised patient record.

Churgin [1994] concluded that if physicians and their staff desired a successful transition from a manual to a computer system, they should first make a firm commitment to the development of new personal skills and work patterns. Furthermore, they should allow adequate time for training and learning the system, and abandon some established patterns that are not appropriate in an automated environment.

2.3.6.2 The Electronic Medical Record at the Mayo Clinic

The Electronic Medical Record Task Force at the Mayo Clinic in the USA was charged by the Mayo Foundation to define the Electronic Medical Record (EMR) for Mayo. The task force then mapped the goals, strategies, and time-lines for implementation of the EMR in the Mayo Clinic. Predominantly composed of caretakers (physicians and nurses), the task force was also assisted by members of Mayo's information systems and administrative departments.

The focus of the effort was care of the patient with the belief that the EMR would improve the process. If designed robustly, it was also believed that it would serve other information needs such as claims, research, education, and practice management.

The recommendations of a report published on 1 January 1993 were accepted by the Mayo Foundation leadership resulting in the generation of a master plan and the creation of the governance structure for implementation at Mayo. The following section will broadly discuss key portions of the report.

- **EMR System model** – The model of the physician's view of the EMR, as described in the Mayo report, represents a conceptual presentation which shows the elements

that should be present on any computer screen through which a physician or other care provider may seek access to the EMR [Carpenter 1994]. It is therefore not intended as a design screen.

According to Carpenter [1994] the screen is divided into three general areas, namely:

- **Identifying information**
  - Current patient
  - Current physician
  - Other useful flags, e.g. medical fund patient
  - Help button.

- **Clinical information**
  - Series for Folders
    - Results information
    - Ordering information
    - Look-up folder (medical literature and medical facts).

- **Personal and functional tools**
  - Series of lists and reminders for the system user as well as buttons for access to functional capabilities
    - Problem lists
    - Task lists
    - Master sheet
    - Hospitalisation information
    - Bed availability
    - Patient location
    - Pharmacy list
    - Electronic mail.

- **Computer system attributes for interactive access to the full medical record** – Carpenter [1994] states that groups of users will need complete access to components of the record. These groups include physicians, physician assistants, nurses, desk attendants, medical secretaries, legal staff, administrators, and investigators. Others, like technicians, appointment clerks, and hospital support service co-ordinators, will need a specified subset of the information.

According to Carpenter [1994] the following technical barriers were identified:

- **The human interface** – The interface is the place where people and machine meet. Therefore, designing the user interface is a major challenge. A graphical user interface (GUI) was chosen.

- **System performance** – Response time for information retrieval/display needs to be in a sub-second time frame. Mayo would, however, incorporate a number of sources in a single display in a highly integrated fashion, a technical requirement that will challenge the retrieval time prerequisites.

- **Speech recognition** – Speech recognition is seen as the most comfortable means of expressing language for humans, but at the time the report was published, the technology was just emerging.

- **Infrastructure** – A complete EMR will present major requirements to existing and future network systems. Data volume estimates can help define those needs.

- **Text processing / analysis** – The largest and richest information resource in the medical record lies in the volumes of text documents. Systems will need to be developed to analyse text from voice/transcription entry and evaluate the meaning.

- **Confidentiality and security maintenance** – It is extremely important to ensure patient data protection.

- **Data and message standards** – A great need for common standards exists. Although several standards bodies are addressing the issue, work is historically slow.

Carpenter [1994] also describes the non-technical barriers that were identified:

- **User acceptance** – It has been suggested that caregivers were reluctantly dragged into the computer world. One of the features that will increase the likelihood of user acceptance, is user involvement in the design and development process. Requisite education systems should be in place as part of every EMR system. Carpenter [1994:164] quotes the following in this regard:

"if you build it, they will come"
"if you build it *right*, they will come"
"if you let them build it, they will already be there".

- **Leadership** – High-level integration of EMR systems requires management systems to co-ordinate it.

- **Dual system** – The co-existence of paper records and EMR components will continue to be a reality, and will require close co-operation and management.

♦ **Workstation attributes for interactive access to complete EMR** – The following workstation attributes were addressed in the task force's report [Carpenter 1994]:

- **The overriding principle** – Workstation must not interfere with the ability of the provider to focus upon the patient and the patient's needs. The provider should not

be perceived as caring for the system instead of the patient. The implications of this attribute are:

- Gain rapid access without significantly breaking off attention from the patient
- Physical presence of the computer system should not intrude on the physician/patient interaction. The computer should blend in
- Information presentations should be naturally screened from patient's view, but it should be easy to enable the patient to see the information display for explanatory/educational purposes.

- **The display** – Full colour display is necessary, where visual impairment is accommodated. Document image display should be provided to permit reading documents that were previously scanned. The system should have the ability to display photos. Minimum display resolution and dimensions should be such that a double medical record sheet could be displayed and read on a single screen. The system should have the ability to scale all images. Diagnostic image display is desirable when electronic versions of these images are available. Image examples might include radiology images, pathology slides, and ultra-sound images.

- **Presentation formats** – Help information should be readily available to the user. Alternative display formats, e.g. problem-based, physiologic systems-based, or chronological format should be presented as options. The form of presentation, e.g. tabular/graphic/flow sheet displays or colour schemes, should be selectable by the user to best fit their needs. Exception lists/alerts should be determined by an individual user's requirements. A GUI is desirable, but should not prohibit the user from using background text based applications.

- **Interaction (Selection, Command, Direction)** – This attribute describes the principal means of interacting with the workstation. Cluttering the workstation with devices should be avoided. The decision to include a device should be based on a

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distinct role for that device, not simply to provide an alternative. The following interaction alternatives are available, namely pointing devices (pen, finger pointing), mice (most common), trackballs (generally not well received), the keyboard (it must be an option), bar code scanners/wands (permit rapid, positive identification of patients), menus versus command line options (both must be offered to cater for novices and experienced users), and finally voice recording (an essential means of capturing information in the future).

- **Entering / adding textual information** – This attribute relates to the means for adding textual information to the EMR, using the devices listed above. The following are available:

  - **Free-form text**

    This refers to the addition of clinical information in whatever sequence the user desires. It assumes the ability to encode some of the text for organisation and retrieval. It is not the best solution, but the most acceptable solution to users.

  - **Selection of coded entries**

    Text is entered by selecting from menus/lists of appropriate words and phrases that are presented by the system in a context-dependent manner. A coded entry must, however, permit the overriding addition of free-form text. The major drawbacks of this kind of text adding are that the user's freedom of expression is limited, it is difficult to express nuance, prior definition of strings for each circumstance is required and it is slower to enter information initially until the user is more familiar with the system.

  - **Dictation of text**

    Information is keyed in by a transcriptionist. Voice recognition is a futuristic alternative. The ideal would, however, be to have the raw recording form as part of the EMR.

- **Keyboard entry**

  Keyboard entry should be provided for in every circumstance. It is generally perceived to be more intrusive in the physician-patient relationship than a manual, pen-based entry

- **Entering / adding other information** – Externally generated data about the patient should be captured. This can be accomplished by providing document scanners near or at the workstation, coupled with the ability to incorporate facsimile information.

- **Other attributes that should be taken into account, are:**

  - **Printed output**

    The printing of prescriptions, summary letters, and health information should be convenient.

  - **Sound output**

    Sound output will be required if a dictation system is embedded in the workstation and raw voice transcript is held in the EMR.

  - **Rule evaluation capability should be provided**

    The application at the workstation must be capable of quick response evaluation of simple, limited, but crucial rule sets.

- **Principles for systems evolution** – The EMR Task Force **[Carpenter 1994]** concluded that an EMR system should "stand the test of time". In order to accomplish this, it is necessary to manage change and to set up and use standards. The system should be easy to use and have consistent system interfaces. Data management policies should be adhered to on an ongoing basis, implying a management process similar to

that of the paper record. Finally, the security aspect must have a high priority, where data confidentiality and integrity should be preserved.

2.3.6.3 COSTAR

COSTAR is a public domain computer-based ambulatory medical record system developed at the Massachusetts General Hospital. Medical data of a patient visit is recorded on a paper-based encounter form and then later transcribed into the computer system by clerical personnel [Barnett 1984; Schoenbaum 1992].

2.3.6.4 The EPR developed at Regenstrief Institute at Indiana University

In this EPR, physicians can view a patient's problem list and laboratory data interactively as flow sheets, allowing easier detection of trends [McDonald 1988a].

2.3.6.5 Ambulatory computer-based record at the Boston Brigham and Women's Hospital

This system provides a summary screen displaying a "patient-at-a-glance" with a problem list, allergies, and medications [Teich 1990].

2.3.6.6 A knowledge-based electronic patient record

To help physicians care for patients with HIV infection, the Department of Medicine at the Beth Israel Hospital in Boston, USA, developed an interactive knowledge-based electronic patient record. This system integrates rule-based decision support and full-text information retrieval with an online patient record [Safran 1996].

This highly interactive workstation allows the physicians at a large primary care practice (30 000 ambulatory visits per year) to use online information resources and fully electronic patient records during all patient encounters [Safran 1996].

The resulting practice database is continually updated with outcome data of approximately 700 patients with HIV infection. As a by-product of this integrated system, statistical

methods have been provided to measure the effects of electronic alerts and reminders [Safran 1996].

2.3.6.7 The Medical Desktop

The Office of Medical Computing at the Buffalo School of Medicine developed a working model of an integrated physician workstation based on a graphically oriented "Medical Desktop". It is meant for personal computers [Litt 1992].

According to Litt and Loonsk [1992] the system gives the user access to much of the information necessary for the practice of medicine. This is done by integrating an electronic medical record (notes, orders, consults, laboratory values, and radiological studies, organised both individually and in a visual chart) with tools such as drug references, clinical manuals, textbooks of medicine, literature searching, expert system decision support, as well as electronic communication. It contains an online help system that facilitates use.

The system has been used to teach students and physicians the methods and potential of computer-based medical information management in order to prepare them for the impact of computers in their practices. It was further used to educate them concerning the imperative for the involvement of all health care providers in implementing these changes [Litt 1992].

2.3.6.8 Pathways Smart Medical Record

An example of a state-of-the-art system is the Pathways Smart Medical Record, developed by HBO & Company in 1996. This system integrates medical knowledge with a graphical user interface environment in an attempt to provide support to physicians during the care process. This program currently supports family practice, internal medicine, paediatrics, and cardiology [HBO 1995].

To document patient encounters, the physician uses a pen-based computer to check off selections displayed on graphical menus and questionnaires. Based on the SOAP model, the on-line menus and questionnaires mirror the actual care delivery process – from medical history, history of present illness and physical examination through differential-diagnosis and treatment plan. Laboratory tests and medications are also addressed. As the physician takes the history and examines the patient, Pathways Smart Medical Record's natural language processor automatically generates text from the underlying data elements selected [HBO 1995].

Each template in the knowledge base describes the characteristics typical of a specific disease category with a history of present illness. This includes a description of symptoms, timing and episodes, co-factors, risk factors, previous evaluation, diagnostic tests performed, and previous treatment. It also includes all the expected background questions such as medical history, habits, immunisations, family history, and review of systems [HBO 1995].

Future support for obstetrics/gynaecology, neurology, and general surgery in the knowledge base is in the pipeline. Automatic translation of discrete data from the knowledge base into multiple languages will also be done [HBO 1995].

2.4 Problems encountered / Lessons to learn

While researching the work already done in the field of the EPR, a thin line of similar problems that were encountered and lessons to be learnt, gradually became evident. In order to fully take advantage of other researchers' successes or mistakes, these problems/lessons were grouped into the following categories:

- Acceptance by physicians
- Physician-patient encounter
- Data capture, content, and structure of the EPR

- Structural expectations of physicians
- Functional expectations of physicians
- EPR component technologies
- Standards and policies
- Privacy, confidentiality, security, and legal issues
- Education.

The problems encountered/lessons learnt will now be listed in each appropriate category.

2.4.1 Acceptance by physicians

- The most promising strategy towards acceptance of the EPR is to focus on those benefits that are greatly valued by users [Van Ginneken 1995]. The EPR is seen as a fundamental tool for physicians and consideration must be given to the patient being a key team member and potential user of EPR-related technologies [Jacobsen 1994]. It is very difficult to sufficiently involve the user in the development stages of an EPR program. Too often, designers try to convince users of the elegance of their ideas. It, however, requires a thorough understanding of user problems to find proper solutions to them [Nowlan 1993].

- It was found that, although computer-based medical records markedly improved the performance of preventive procedures by committed physicians, many physicians using computer systems failed to make use of the resources. The reasons were complex, but it was stated that designing an EPR system should make provision for personal behaviours and physician personalities. The design should also focus upon administrative changes in order to implement the powerful tools more effectively [Tape 1993].

- It will require talent, diplomacy, and extensive support data to persuade medical practitioners that the difficulties encountered with the change of their practices will be worthwhile. It is, however, necessary that the changes do take place. As mentioned

before, the physicians are awash in paper – they drown in information. Patients are at risk from errors in services, delays in the transmission of life-critical information, services are duplicated unnecessarily, and the health service providers do not have access to their health history. The EPR will resolve many of these problems [Milholland 1992].

- If physicians and their staff desire a successful transition from a manual to a computer system, they should first make a firm commitment towards the development of new personal skills and work patterns. Furthermore, they should allow adequate time for training and learning the system, and abandon some established patterns that are not appropriate in an automated environment [Churgin 1994].

- A gradual change as opposed to a "big bang" approach towards implementing EPRs in medical practices has the advantage that a need for planning is recognised. It is easier to assimilate change in small doses [Gillies 1995].

- All practices will benefit from the use of a single-user EPR system as a pilot implementation.

- Reminders on computers will not persuade physicians to perform procedures that they fundamentally disagree with [Tape 1993].

- Physicians and people in general, find it difficult to adjust to a paperless record. The challenge of learning to retrieve needed medical information from an unfamiliar computer system is an overwhelming task for physicians [Tape 1993].

- Some physicians stated that for fear of appearing incompetent in the patient's eyes if they failed to find the needed information, they intentionally avoided using the computer displays in the patient examining rooms [Tape 1993].

- In order to ensure that more general practices use a computer for direct patient care, it is important that the Government should fund the initial hardware and software costs. They should also provide financial incentives for physicians based on their information management skills [Kidd 1995].

- The financing of the development and implementation of an EPR is a challenge in an economy where health services are already viewed as too costly [Milholland 1992].

- For an electronic record to become widely acceptable, it must be truly portable. The medical record must be able to accept data of any classification from any country. It should also be able to accept input in any common (European) language and be able to translate the record as accurately as possible into other languages. The medical record should also be capable of operating on a wide variety of computer hardware and software [Kalra 1994].

- The existing computer systems that GPs use in their practices, determine the ease of acceptance of an EPR system. The varying levels of skill and expertise within and between practices, present a major problem in relation to the flexibility of the existing systems. Some existing systems can be adapted easily to the demands of a new system, while in others, the new system presents a major increase in workload. This has resource implications in the majority of practices [Rigby 1995].

- Many healthcare information systems fail (at least partially) [Heeks 1999]. Many reasons are given on why these systems fail [Sauer 1993]. Whether a system succeeds or fails, however, depend on the degree of mismatch between the conceptions in that system's design and the realities into which it is introduced. The mismatch may be assessed along seven main dimensions, namely information, technology, processes, objectives and values, staffing and skills, management and structures, and other resources. Three conception-reality gaps that make failure more likely to occur are [Heeks 1999]:

- When health care information systems (HCIS) derived from hard rational models of organisation meet a different behavioural reality
- When HCIS derived from the private sector are transferred to public sector health care organisations
- When HCIS derived from one country are transferred to another country, especially from an industrialised to a developing country.

2.4.2 Physician-patient encounter

- The EPR should not supplement, but fully replace the PMR. It should be used directly by the physician; only then can it reach its full potential [Barnett 1993].

- In comparison with the traditional paper record, it was recorded in some cases that the physicians spent more time recording data in the computerised medical record. Interaction time with the patient was also less.

- Using an EPR system during a physician-patient encounter resulted in the physician changing from a conversational to a blocked pattern working style. This change had at least three consequences:
  - Both conversation and the flow of ideas and associations are interrupted
  - These interruptions disrupt communication between the physician and patient
  - The physician must remember more information before recording it.

  Both patient and physician can experience stress as a result of the above-mentioned consequences and the relationship between them can be damaged [Warshawsky 1994].

- After introducing the computer into his practice, a physician's patients complained that he was paying more attention to the computer than to them, in spite of typing the entire encounter without once losing eye contact. In another case, when asked whether computers make physicians less personal [Rethans 1988], the vast majority of respondents had favourable opinions about the EPR and its impact on the physician-

patient relationship [Solomon 1993]. It therefore seems that this is a complicated issue. It should nevertheless always be born in mind that the workstation must not interfere with the ability of the provider to focus upon the patient and the patient's needs. The provider should not be perceived as caring for the system instead of the patient [Carpenter 1994].

- In Australia, patients' attitudes towards the computerisation of family practices led to the following results:
  - 91%: did not feel uncomfortable about their physician using a computer in the room during consultation
  - 95%: were not concerned that their physician kept notes on a computer file instead of using a paper record
  - 6%: would be less able to tell their physician about personal matters when he/she used computerised medical records
  - 97%: they would not consider changing their physician because he/she used a computer [Kidd 1995].

2.4.3 Data capture, content, and structure of the EPR

- Greater specificity in the definition, architecture, and functional capabilities of EPRs are urgently needed to guide developers, vendors, and purchasers of EPR systems.

- EPRs must be clinically based and driven. Automated abstracts of patient records are not adequate to meet patient record needs.

- More data should not be captured just because technology makes it easier to do so. Part of the design process for EPRs must involve defining record content and redesigning record format [Berwick 1994; Weed 1989].

- The form of data captured is critical. Merely computerising text is not sufficient to meet the EPR requirements [Essin 1993; Collen 1993; Rector 1993; Barnett 1993].

- Keyboard entry should be provided for in every circumstance [Carpenter 1994].

- Difficulties are experienced with the downloading of existing demographic patient data that can cause much extra work for clerical personnel. The same applies to the conversion of existing paper-based chart data to the EPR format [Churgin 1994]. Externally generated data about the patient should be captured. This can be accomplished by providing document scanners [Carpenter 1994].

- The EPR record should generally contain a narrative account of the individual encounter, as well as test results. The practitioner's thoughts in an individual consultation are given some structure by coding and classification [Kalra 1994].

- Although a wide range of clinical terms in a computer dictionary will help creating some freedom of expression, searching through so many terms for a phrase is impractical. A vocabulary alone does not solve the problem of the underlying record structure into which those words will be placed [Kalra 1994].

- The patient record should integrate lengthy notes into one source that may be shared by the health care team. The patient record has been described as the principal instrument for ensuring co-ordinated, continuous and comprehensive care [Liaw 1993].

- When careful attention is given to the design and content of an EPR, using the system may [CPRI 1996]:

  - Save lives
  - Focus attention on allergies
  - Identify when a patient takes drugs that will interact
  - Assist the physician to understand chronic illness in order to explain symptoms

- Save time in the medical assessment of patients' health condition, as the medical history is known
- Assist in creating immunisation programs
- Assist in cancer research.

2.4.4 Structural expectations of physicians

Structural refers to how specific tasks are done by a computer system [Bolton 1996].

- General Practitioners want a system which will improve their efficiency by saving time, improving practice efficiency, and generating more money with less work [Bolton 1996].

- An EPR should be reliable [Bolton 1996].

2.4.5 Functional expectations of physicians

Functional refers to the system's ability to perform a specific task [Bolton 1996].

- The EPR should play a substantial role in practice management, specifically in the following tasks [Bolton 1996]:
  - Accounts rendered
  - Debt recovery
  - Prompt for change of address
  - Time management
  - Practice organisation.

- The EPR should assist in patient management. Examples of how this expectation can be achieved, is by providing a drug database where prompts about possible interaction with other pre-existing patient medication can be generated. Pictures of pills could be presented for easy identification and prescriptions should be generated.

- The EPR should ensure quality assurance by providing for:
  - Medical history summary
  - Instant medical reference
  - Patient recall generation (with labels)
  - Prompting during consultation
  - Patient education media
  - Interfaces with path labs [Bolton 1996].

- Other functional expectations are effective communication between GPs, provision for audits and planning, patient population and disease profiles, and research possibilities [Bolton 1996]. Telecommunication capabilities for information transmission are required, as well as cellular phone support [Jacobsen 1994].

- The EPR should facilitate management by exception (intelligent summaries, graphs) for length of the treatment/lifetime of the patient [Jacobsen 1994].

- Voice, video, data, and images should be integrated into the EPR [Jacobsen 1994].

- Access to external knowledge-bases would be helpful [Jacobsen 1994].

2.4.6 EPR component technologies

EPR component technologies continue to develop at a rapid pace.

- Significant progress is being made in the area of data acquisition:

  - Clinical workstations are increasingly robust so that they provide physicians with ever-greater incentives to interact with the computer and EPR system.

  - Pen and pad technologies, as well as portable workstations are already being used to offset previously observed resistance to data entry.

- Handwriting and speech recognition also loom on the horizon as potential aids to data acquisition, but their actual value remains to be determined [Tang 1994].

- Progress has also been achieved with respect to establishing the information infrastructure that is essential to EPR system functionality, namely to provide access to a multitude of information resources, and the transmission of patient data among institutions. Much of the backbone of this infrastructure (through Internet, commercial on-line services, community health information network, and telemedicine networks) are in place, but in some countries work still remains [Detmer 1995].

- A good system user-interface is a pre-condition for an acceptable EPR. Looking at the user-interface from the input, output, and related issue views [Bolton 1996]:

  - Input
    - An EPR system should have a graphical user interface
    - There is a desire for voice recognition
    - Automatic data entry from external devices and service providers should be possible
    - Simplicity is required – this implies minimise clicking of the mouse.

  - Output
    - Fast response time
    - Portable.

  - Related issues
    - Simple to operate
    - Easy to learn
    - 'Foolproof'
    - User friendly.

- According to Jacobsen [1994]: "The EPR is a vision, a strategy that may encompass many application systems, infrastructures, technologies and data access/decision-making support tools which the professional workstation needs to approach in supporting care delivery". Workstations can be seen as enabling technologies for the EPR. Therefore workstations should:

  - Support entry/update/access to patient assessments/history/physical/health status information
  - Facilitate plans of care throughout the course of treatment from any point-of-care, even countrywide
  - Support documentation and clinical data gathering by user input and medical technology interfaces
  - Access views of patient information (trending and graphing)
  - Support advance decision making capabilities
  - Access external databases for knowledge.

  Workstations should also have the following features [Jacobsen 1994]:

  - Lightweight, portable workstations with radio frequency and cellular capability
  - Tying into cable networks of local community
  - Easy to use, intuitive systems
  - Easy tailored for each discipline-specific use
  - Terminology standards essential for communication within community setting
  - Patients will also document their own health histories, responses to treatments, and medications for review by physicians.

2.4.7 Standards and policies

- The development of standards regarding EPRs still needs much attention [Detmer 1995; Jacobsen 1994; Bolton 1996].

- Implementing EPRs is a complex process. One of the early steps that should be taken, is agreeing on standards for data capture [CPRI 1996b].

- Standards are further needed for [CPRI 1996b]:

  - Identifying patients, providers, and care sites
    - Unique, citizen identifiers (such as an identification number, accompanied by a confidential personal identifier number (PIN) of several digits) that can be used for health purposes, would facilitate development of longitudinal patient records in EPR systems and in research databases [Detmer 1995].
  - Transferring messages across computers
  - The format of the message itself
  - Codifying text
  - Describing the content of the patient record.

- The absence of standards for the clinical record and the lack of support from government and professional organisations, result in the use of a variety of competing computer operating systems, hardware platforms, user interfaces, and software tools. Little consideration has been given to a system supporting an *open architecture*[4].

- Rigby *et al.* [1995] remarked that there has been no common purchasing strategy for hardware and software within general practices.

[4] An open architecture implies a standard that would allow computer hardware and software products of many different manufacturers to function together [Barnett 1993].

2.4.8 Privacy, confidentiality, security, and legal issues

- The likelihood that unauthorised use will be made of information is a function of its value and the number of people who has access to it. Consolidating valuable private information, such as medical records, into large databases increases both of these risk factors simultaneously [Anderson 1999].

- National policies needs to be established to deal with ownership of data, to develop unique health identifiers, to ensure adequate safeguards for protection of patient privacy and to clarify assignment of liability for problems arising with the use of clinical decision support systems. Lack of these policies slows down the development of EPR systems [Detmer 1995].

- Centralising data also brings safety problems. Large centralised systems may fail less often, but when they do break down the results may be much more serious than with decentralised systems [Anderson 1999].

- As far as secondary uses of medical records, as in research, clinical audits, quality management, and administration are concerned, an agreement should be reached with commercial providers of health data to ensure that no personal health data would be identifiable to anyone outside that provider [Anderson 1999].

- Safe clinical systems require a design team that can operate openly with a high level of user collaboration and consultation [Anderson 1999].

- The Caldicott Committee-Report identified six principles to follow regarding patient-identifiable information [Caldicott 1997]:

    - **Principle 1:** Justify the purpose(s) for every use or transfer of patient-identifiable information

- **Principle 2:** Don't use patient-identifiable information unless it as absolutely necessary
- **Principle 3:** Use the minimum necessary patient-identifiable information
- **Principle 4:** Access to patient-identifiable information should be on a strict need-to-know basis
- **Principle 5:** Everyone with access to patient-identifiable information should be aware of their responsibilities
- **Principle 6:** Understand and comply with the law.

- Protecting confidentiality of private health information is critical to the adoption and use of EPRs. Breaching of confidentiality could lead to loss of employment and housing, health and life insurance problems, and social stigma [CPRI 1996].

- Key factors that enhance protection of confidentiality in the computer environment are [CPRI 1996]:

  - Adopting appropriate security measures
    - Formal information security programs

  - Instituting technical and administrative controls
    - Positively identify the user
    - Verify authorisation
    - Determine legitimacy of use
    - Restrict retrieval
    - Use of encryption
    - Track all access

  - Legislating privacy laws and tougher discriminative controls
    - Some patients are not allowed to see their own records.

- Fingerprint or voiceprint security features will become essential in EPR technology [CPRI 1996].

- If medical records from a whole range of sources can be put together, a vast file could be generated which covers a patient's whole medical life. Unfortunately there are fears, especially from patients, about such a "Big Brother" approach to their private health information. Therefore one should give attention to security and legality [Kalra 1994].

- A computerised medical record admissible in court should have a watertight method to identify the author. This method is known as an electronic signature. It should not be possible to erase or alter previous entries completely, although they could be altered. The electronic medical record system should be secured against unauthorised access. An agreed set of information may be recorded every time new data is entered, e.g. time, date, the provider, and who may view it [Kalra 1994].

- The legal and ethical issues surrounding the EPR are complex and should be carefully addressed before the record is capable of being used in a widely acceptable way [Kalra 1994].

2.4.9 Education

- Massive training is necessary for physicians to become computer literate and to integrate technology into clinical practice [Jacobsen 1994].

- Three key areas of education about the concept of EPRs remain to be addressed [Detmer 1995], namely:

  - Demand for individuals trained in health Informatics continues to outstrip the supply

- Although information technology and training on its use is increasingly evident in health professional schools, the overhaul of curricula to reflect the changing skills and competencies that future physicians will need, are not yet widespread
- As information technology continues to disseminate throughout society-at-large, there is an increased likelihood that patients will access EPRs and will therefore need education in the use of the patient record and health information resources.

Concluding this section on problems encountered and lessons learnt, the EPR has been described as moving from the realm of "off-beat visionaries" and the view that it was too difficult to even attempt, to an "established-endorsed probability" [Duncan 1994]. It is "a component of most strategies for the provision of medical care to large populations" [Churgin 1994].

EPRs are therefore essential to health care. Until and unless EPRs are developed and broadly implemented, there will be a limit in the capacity to develop truly integrated delivery systems, to make each and every clinical decision as effective as possible, and to reach health care's next plateau, namely evidence-based medicine [Detmer 1995].

2.5 Future developments – the information tool of the future

From the discussions in this thesis, the author is of the opinion that the current paper medical record must be replaced in order to integrate all patient information into a unified electronic health record. This is necessary if patients are to benefit fully from the electronic age [Kalra 1994].

Which way should the EPR go? Van Ginneken [1995] answers this question in the following way: "Perhaps we should temper our enthusiasm about the potential of the EPR and take smaller steps in its development. User-acceptance should have priority above all. In the mean time, new insights and developments may bring the remaining goals within reach".

Van der Lei *et al.* [1993] mentions the following developments for the future regarding the EPR:

- The integration of computer-based patient records with decision support modules and research modules
- Professional organisations are working on standards to allow the transfer of the complete patient record from one system to another when
  - The patient moves from one GP to another
  - The GP purchases another system from a different vendor.
- To improve the continuity of care by sharing data (possible shared patient record), studies are being done to allow GPs and specialists who see the same patient to have access to each other's patient record. Related to this, Kalra [1994] states that general practitioners and hospitals will need to directly access specialised types of data held on their patients. The most obvious example is x-ray data. It should be possible to hold the electronic address of a chest radiograph taken at the local hospital within the computerised patient record. The computer would then dial the hospital automatically. After the exchange of security measures, the radiograph should be presented on the screen. The same principal can be applied to other information and images.
- Data security and privacy (of both patients and physicians) still need much attention. The following remarks should be taken into account:
  - Privacy is best ensured when clinical data is anonymous (although total anonymity not possible)
  - Patients should give their consent before clinical data from computer-based patient records is transmitted to an aggregate database
  - Tracing of individual patient should be done only through the physician who recorded the initial clinical data.
- Future work in the EPR-area should provide for personal behaviours of all the role players and should focus on administrative changes in order to implement the powerful tools more effectively [Tape 1993].

The information tool of the future that may transform medicine, could have the following characteristics [Smith 1996]:

- It must be able to answer highly complex questions and must therefore be connected to a large valid database
- It will be electronic, but fast, portable, and easy to use
- It needs to prompt physicians in ways that they find helpful rather than demanding
- It will meet a need for psychological support and affirmation.

The physician's tool of the future might be some sort of combination between the patient record and the Internet, with the physician and the patient positioned together at the intersection, not having to pay attention to the technology [Smith 1996].

2.6 Summary

In Chapter 2 a literature study was done to investigate what has already been done in the rest of the world regarding the EPR. Firstly data models were discussed, with special attention given to the Template, Hindsighted Practice Guideline, and Foresighted Practice Guideline Models.

Secondly a few examples were given of existing EPR-type systems and of research studies that were completed in this field. The problems encountered and lessons learnt as a result of this existing research, were then listed and briefly discussed.

The chapter was concluded with a view to the future – future developments concerning the EPR and the information tool of the future.

Chapter 3 will attempt to answer the question "*What is the status of the EPR in South Africa?*". This will be done by first describing the current manual clinical record system in

use in the majority of general practices in the country, to be followed by an investigation into possible EPR systems developed in South Africa.

Chapter 3

The Manual and Electronic Patient Record: South Africa

3.1 Introduction

Chapter 2 gave insight into what has been happening in the rest of the world regarding the EPR. What is the status of the EPR in South Africa? This chapter will begin to address this question (it will be continued in Chapter 4). First the current manual systems generally used by general practitioners in their practices in South Africa will be investigated. This knowledge is necessary in order to have a better understanding and perspective of the South African EPR situation, as will be addressed in the rest of this thesis.

The chapter will conclude with an overview of EPR systems already in use in South Africa.

3.2 Current manual systems in South Africa

In explaining the current manual systems in South Africa, one specific source will be used, namely *Family Practice Management* written by G. J. Pistorius & C. W. I. Pistorius in 1986 [Pistorius 1986]. The reasons for using only one source are two-fold: first, as far as could be determined, this book is the only one addressing the manual clinical record system as used in South Africa. The second reason is that the book is widely used and accepted in South Africa. Evidence is the use thereof at several South African universities in the tuition of Family Practice. As the whole of section 3.2 is based on this source, no further reference will be made to it.

In order to have a practical and effective clinical record system, the two magic words are: *practical simplicity*. Such a system should be very simple – if it is complicated, no physician will use it. As mentioned in Chapter 1, they do not have any time to waste. It is important to have a practical, functional framework on which the details of each practice and every circumstance can be built.

Certain principles of a clinical record system are identified, namely:

- Provision should be made for the unique problems of the family practitioner.
- A *maximum* system does not equal an *optimal* system. A *maximum* system would have too much detail to function effectively. An *optimal* system requires simplicity.
- A written task description and explanation of the working of the system is necessary. This is a requisite to accommodate any new partner or staff member.
- No system can function without continuous self-discipline. The simpler the system, the easier it is to apply self-discipline!

Additionally, clinical record systems should comply with ten important requisites:

- Complete and concise noting
- The noting of all work undertaken outside the surgery
- Efficient filing
- Co-ordination with an accounting system
- Provision for a family file for the particulars of a whole family
- The filing of specialist and other reports to expedite immediate and automatic recovery [Van Biljon 1965].
- Provision for continuous care by recording relevant data chronologically and meaningfully
- Practical format
- Durable files because of the repeated handling over a long period of time

- Transferability – the data on the file must be clear and concise to allow another practitioner to easily understand the patient's whole history, or the course of a disease.

3.2.1 The Elements of the system

The elements of the clinical record system include:

- The cover, with its contents
- The prescription pad
- Obstetric notation (will not be discussed further)
- Miscellaneous forms.

Each of these elements will now be discussed briefly.

- **The cover** – The cover consists of a standard A4 cardboard file. A label is attached to the side of the cover indicating either an alphabetical of numeric symbol. This symbol represents a patient identification and is used for filing purposes. The cover contains the following:

  - Clinical record card
  - Problem list
  - Patient registration form
  - Copies of prescriptions and reports of treatment performed outside the surgery
  - Reports from specialists
  - Miscellaneous items, for example flow charts, diagrams, and E.C.G reports.

  The clinical record card and the problem list are secured on the left-hand side of the opened file cover, while all other data is on the right hand side. Data relevant to a complete family is kept in one folder. Each member of the family, however, has a

separate clinical card and problem list. If a separate file cover is used for each member of the family, the pre-condition is that all the files of a family are kept in a larger container cover to allow all data relating to a particular family to be at hand.

For the sake of confidentiality, certain aspects of the socio-graphic component of the patient are noted in pencil on the inside left page of the file cover. These include aspects that can be of interest to the physician during consultation, for example the names of children and home language. All other socio-graphic information concerning the individual patient will appear on his clinical record card.

The covers with their content are generally filed in modern cabinets with broad drawers. Inactive files of patients, who have not visited the practice for some period of time, can cause problems, specifically regarding filing space. Identifying these inactive files is, however, a major problem in manual record systems.

- **Clinical record card**

  An A4-card (any type of hard paper or thin cardboard) is used for the clinical record card. This card consists of two components, namely the socio-graphic component and the clinical component. The socio-graphic information that generally appears on the card include the name, address, a reference number, date of birth, occupation, marital state, church denomination, and allergies.

  Space for the clinical component may be found on that portion of the front side of the clinical record card not already taken up by the socio-graphic information, as well as the whole of the back. Initially this component consists of a blank ruled sheet with a margin wide enough for a date stamp. This will allow any physician to follow his own personal style of clinical notation.

- **Problem list**

  A separate problem list is used for each patient. The size and type of paper is the same as for the clinical record card. A condensed socio-graphic component, consisting of only the patient's name, reference number, and date of birth is used at the top of the page. The problem list is divided into five columns: Number, Problem, Problem date, Outcome, and Outcome date.

- **Patient registration form**

  This form is used to obtain first-hand socio-graphic information from the patient. The patient must therefore complete the form personally during his/her first visit to the practice.

- **Copies of prescriptions and reports of treatment performed outside the consulting room**

  The prescription book (that allows for duplicate prescriptions) has a dual function, namely prescriptions and the clinical and financial notation of work done outside the consulting room. The prescription function is self-explanatory. The notation of work done outside the consulting room and the role of the prescription book in such cases needs some elaboration (see the section on the prescription book below). In either case, the duplicate prescription will be attached to the right-hand side of the record file.

- **Reports from specialists**

  On receiving a report, the physician reads the report and underlines the important and relevant facts/findings. The receptionist then transcribes the underlined text in red to the specific patient's clinical record card against the date of that specific examination/investigation. This date often differs from the present date or the date of the report. In the case of lengthy reports, where it is not feasible to summarise it in a few words, the physician can underline the referring physician's name. The

original report will then be filed on the right-hand side of the clinical file. These measures ensure immediate and automatic availability of all relevant reports.

The bulkiness of radiology reports and radiographs can be problematic. To overcome this problem, the envelope with the radiographs, as well as the duplicate report are handed to the patient. The original report is then filed in the way as described above.

- **Miscellaneous items, for example flow charts, diagrams, and E.C.G reports**
  Flow charts, diagrams, and E.C.G reports are examples of a whole group of miscellaneous items that a physician can add to his/her system. All these forms are attached to the right-hand side of the file cover.

- **The prescription book** – In order to illustrate the role of the prescription book in the notation of work done outside the consulting room, a home visit will be used as an example: The physician issues a prescription in the usual way immediately after having completed the physical examination. The original prescription is torn out and handed to the patient. Immediately after that, the clinical findings of the home visit are entered on the back of the remaining duplicate in the prescription book. The fee for that specific visit is also entered in the same manner. Should a prescription not be found necessary during the home visit, the clinical findings, as well as the fee, are entered on the original prescription form.

  The next morning, all the duplicates of the work done outside the consulting room on the previous day are handed to the receptionist. After the receptionist has debited the specific patients with fees as indicated, each duplicate is filed on the right-hand side of the patient's file. At the same time an entry in red is made on his/her clinical record card, with a mention of the number of the prescription form. This action ensures the chronology and completeness on the clinical record file.

A similar procedure should be followed for hospital visits, operations, and confinements.

- **Miscellaneous forms** – Miscellaneous forms include letterheads, referral letters, certificates of absence, and the patient reference card (a card the size of a credit card to provide the patient with his/her reference number).

3.2.2 Functioning of the system

An extremely important principle to follow when using a clinical record system, is *immediate notation*. To illustrate this principle, the following paragraphs will provide an indication of the manner in which a typical consultation in the surgery may be conducted.

At a family's first visit to the consulting room, the member responsible for the family must complete the patient registration form. The receptionist will inquire which member of the family is going to consult the physician. She then prepares a file by:

- Allocating a reference number to the family, transcribing it on a label and attaching it to the top part of the left inner page of the file cover
- Completing the patient reference card by filling in the relevant name and reference number and handing it to the patient
- Transcribing the relevant socio-graphic data in the prescribed manner from the patient registration form to the clinical record card, problem list, and to the inner page of the file cover
- Attaching the clinical record card and problem list to the left-hand side and the patient registration form to the right-hand side of the file cover
- Stamping the date in the left margin of the clinical record card.

During the consultation, the physician will typically note his/her findings on the record card and the problem list. The results of any special investigation conducted by the

physician himself/herself will be noted in red on the record card. If so required, a prescription will be issued to the patient. The duplicate prescription will be attached to the right-hand side of the record file.

3.2.3 General clinical notation

One absolute requisite for meaningful notation is to work according to a definite scheme. The advantages of complying with this requisite, are completeness and time-savings.

The model that is recommended to medical students in Family Medicine at the majority of South African universities, is the SOAP-model [Weed 1969] (see Chapter 1). This model is also recognised in the rest of the world. The SOAP-model, as applied in general practices in South Africa, will now be discussed briefly.

- **S = Subjective (History)** – The Subjective part consists of two components, namely the socio-graphic and the clinical component. The socio-graphic component involves the data on the clinical record card, the file cover, and the patient registration form (as discussed earlier in this chapter). The clinical component in turn, consists of three parts, namely:

  - Main complaint
  - Previous medical history
  - Collateral history.

  The main complaint is the complaint that brought the patient to the physician and not necessarily the most serious problem. The previous medical history includes previous illnesses, operations, accidents, injuries, investigations, drugs, and allergies. The collateral history addresses issues like the family's medical history, a general profile (e.g. education level, hobbies, social habits), and an overview of systems. These systems are:

- Psyche
- Central nervous system
- Eyes
- Ear, nose, and throat
- Cardio-vascular system
- Respiratory system
- Breasts
- Gastro-intestinal system
- Urological system
- Genital system
- Musculo-skeletal system
- Ectoderm
- Endocrine system
- Blood and reticulo-endothelial system.

- **O = Objective (Examination)** – The objective part will be noted on the clinical record card while the patient is getting dressed. It should be noted quickly and systematically. This examination data can be categorised in the following way:

  - General appearance
  - Basic relevant parameters (length, mass)
  - Vital signs (temperature, pulse, respiration, blood pressure)
  - Examining of systems
  - Special investigations self-performed.

- **A = Assessment** – During assessment the problem list (as discussed in section 3.2.1) is updated, and a summary is made on the clinical record card involving diagnosis, differential diagnosis, etc.

- **P = Plan** – The main purpose of the plan is to recommend solutions. This is done in three parts, medically known as Dx, Rx, and Cx:

  - Dx: Diagnostic measures (self or referred), e.g. E.C.G. investigation
  - Rx: Therapeutic measures (self or referred), e.g. prescription, operation
  - Cx: Patient counselling/information (also Weed's [1969] "Parameters to follow", displayed in flow sheets).

Follow-up consultations are noted by using a limited SOAP version.

In the next section an investigation will be launched as to the possible existence of EPR systems in South Africa.

3.3 EPR Systems in South Africa

The term "electronic patient record" (or EPR) is not a familiar or generally used term in South Africa. Although many aspects of daily life are rapidly being computerised, this concept seems to be foreign to the man on the street. Despite this observation, it became evident that (although sometimes behind the scenes) work *is* being done to change the situation.

The discussion will be based on a workshop presentation at a Medical Informatics Congress held in Seoul, Korea, in 1998. Three systems will be discussed, namely the MEDITECH system as used by AngloGold Health Services, the Brainware98 system, and the n-Genius system.

3.3.1 Progress toward the EPR in Africa

At a congress held in Korea in August 1998 on Medical Informatics (Medinfo '98), a workshop was held where representatives were asked to report on the progress of the EPR in their respective countries/continents. Two South Africans, namely Dr Michael

Power and Mr John Tresling, compiled an introductory presentation with the title "Progress toward the Computerised Patient Record in Africa" that was presented by Mr Tresling.

In this presentation it was stated that throughout Africa there was little available to spend on health care and even less to spend on health care information systems. Although health care information systems exist in Egypt, most work in this area in Africa was done in South Africa, the country with the most developed economy on the continent.

As far as the private health care industry was concerned, the presentation stated that expensive Information System projects had not met the expectations in the past (as was mentioned in Chapter 1). Therefore most of the systems in use concentrate on administration and financial control. As a further result of the inability to meet expectations, the tendency remained to adapt rather than adopt systems, and to still integrate paper records in health care systems.

The presentation highlighted a South African Mining House, namely AngloGold, which is deemed to have a full EPR in place in the next 3 – 5 years. In the following section, this claim will be investigated.

3.3.2 MEDITECH as used by AngloGold Health Services

AngloGold Health Services service three regions of the AngloGold Mining House, namely the Free State Region, the Vaal Reefs Region, and the Western Levels Region. In the Free State Region the service is directed towards a hospital in the city of Welkom, in the Vaal Reefs Region towards a hospital in the town of Orkney near Klerksdorp, and in the Western Levels Region towards a hospital in Carltonville.

AngloGold is the largest South African user of a system called MEDITECH Health Care Information System (HCIS). This system consists of a vast number of modules to be used in the Health Care Industry. AngloGold uses twenty-one of MEDITECH's modules, of

which the Admissions, X-ray, Laboratory & Radiology, Material Management, Stock Control and Patient Care Inquiry modules can be highlighted. As a result of the fact that this information system is too involved, and a major part of the system is not applicable to the interest at hand, the EPR contents of the system will be explained briefly with the aid of the Patient Care Inquiry (PCI) module.

PCI is a view-only application that displays information collected throughout the MEDITECH's HCIS. It is promoted as featuring the following:

- Up-to-the-minute clinical and patient care information
- Patient-oriented displays
- Data displayed in summary to detail format
- Colour tables and graphs
- A split-screen capability for comparing information
- Multiple print features
- User-adjustable time periods for viewing results
- Multi-level, organisation-defined security
- Automatic compilation of patient lists for fast, accurate and versatile patient identification.

PCI gathers and assembles the following types of patient information:

- Orders
- Administrative data
- Current medications
- Medication history
- Clinical highlights
- Nursing documentation
- Record of patient's hospital visits (with abstracts)
- Admissions information, such as demographics and insurance

- Laboratory data
- Microbiology data
- Anatomical Pathology data
- Blood Bank data
- Radiological examination data
- Recent clinical results
- Ancillary departmental orders and results
- Departmental clinical reports
- Nursing care details captured using the Handheld Point of Care Computer.

As mentioned before, this system has mainly been used in AlgoGold hospitals. A pilot system is, however, almost in place for creating medical stations at the mines. The idea is to capture demographic and basic medical information about workers at the mines themselves, in comparison with only being able to capture the information at one of the above-mentioned three hospitals. These stations will be adapted to use seven of the existing MEDITECH modules. In future, in addition to supplying all the mines with a MEDITECH station, they propose to have multiple clinics connected as well.

Although the Practice Management Software module provides benefits like patient scheduling and registration, on-line eligibility and treatment authorisations, recording of treatments and patient payments and e-mail communications, the MEDITECH system is, as far as could be determined, not applicable to the needs of private practice. In the Free State the major users of the system are the Universitas and Pelonomi Hospitals.

3.3.3 Brainware Health

In the requirements analysis phase of the research, as will be discussed in Chapter 4, physicians listed medical computer programs that were in use in their practices at the time. Two of the programs mentioned, were Mass and Medit and physicians indicated that they were used for financial and administrative purposes only.

Since the research, as described in Chapter 4, was undertaken, new developments have taken place. In 1998 Brainware Health, a division of Brainware Ltd, a JSE (Johannesburg Stock Exchange) listed company, took three existing medical systems, namely the above-mentioned Mass and Medit and a third one, called Orion (mainly used in the Western Cape) and combined them to form a brand new system called Brainware98. Where the original systems were DOS based, Brainware98 is a Windows-based clinical and management system directed towards the medical practice. As far as this thesis is concerned, one of the major changes in comparison with the original systems, is the greater emphasis on clinical record taking. Where the original system only addressed the clinical record in a very modest way (for example by providing for the entry of allergies, and a memo-type field for clinical notes), Brainware98 changed all this in making provision for many additional clinical record features. Examples are the provision for separate fields for the basic parameters and vital signs, email support for pathology reports, and many more. Another positive feature is that it permits, or rather requires, customisation for each individual practice. A number of fields are provided where the physician can specify information relevant to his/her specific situation. Brainware98 has an appealing graphical user interface.

Where existing medical systems in South Africa in the past mainly addressed the administrative and financial aspects of the medical practice, Brainware98 combines this information with a relatively extensive clinical part. It appears to be a professional and comprehensive system. The clinical information is, however, spread across the whole system. Different clinical fields appear on different screens, sometimes combined with information not directly applicable to a clinical consultation. In order to be able to utilise the clinical section, an extensive knowledge of the system, as customised, is therefore required. No provision for entering the consultation according to the SOAP model has been made.

No official figures are available to indicate how many physicians in general practice use Brainware98. Those physicians who had one of the pioneering systems (Mass, Medit or Orion) in use, could initially (for a short period of time after its introduction in September 1998) qualify for a rebate when purchasing the new Brainware98 system. The cost of Brainware98 is R6000 (price as in May 1999). An additional R2000 is required for compulsory training of a physician and two people of his/her choice. Those with the original Mass, Medit or Orion programs in use in their practices would have to undertake an additional capital expenditure, in most cases even greater than the original one, in order to be able to make use of the new program, Brainware98.

3.3.4 n-Med and n-Genius

In March 1998 three companies, namely PDS, MBM, and MedSolve amalgamated to form a new company, named n-Med. PDS previously marketed the MultiDoc program (Windows-based), MBM marketed the Ultimate Medics program (Windows-based), while MedSolve marketed the program with the same name, namely MedSolve (DOS-based, but Y2000 compatible). MultiDoc and MedSolve are two financial/administrative medical programs mentioned by physicians in the requirements analysis phase as described in Chapter 4.

Under the new management team of n-Med their new Windows-based financial/administrative medical program, n-Genius, was developed and released in December 1998. Further development is still in progress. Although n-Med will market n-Genius at a price of R7500 (price as in May 1999) to prospective new buyers in future, the original three systems (MultiDoc, Ultimate Medics, and MedSolve) will still be maintained. Provision has been made to accommodate physicians who have one of the above-mentioned programs running in their practices and wish to convert to n-Genius. According to a company representative, a MedSolve environment can easily be adapted to n-Genius, while it is trickier with the other two programs. As an incentive, a physician, who already has one of the three programs and wishes to convert to n-Genius, will be

granted a 50% rebate if he/she had a maintenance contract for their original program. A rebate of 25% will be granted if no such maintenance contract existed.

Although their existing products are all geared towards the financial and administrative functions performed in a medical practice, n-Med intended to develop a so-called "clinical interface". The ultimate idea was to present this clinical interface as a separate model running alongside n-Genius, both using the Internet as communication medium with each other, and with all the relevant role players in the Health Industry. In the middle of 1999, however, the company decided to focus on the expansion of their existing products. All new developments were then suspended.

3.4 Summary

This chapter investigated the status of the EPR in South Africa. It started with a description of the current manual clinical record system generally used in general practices in South Africa. This was followed by an investigation into the existence of EPR systems in use.

Referring to the levels of an EPR [NHS 1998] (section 1.4), the author is of the opinion that levels one, two, and three may have been reached in South Africa. It is concluded that, although interest in the topic exists, EPR systems are not yet used to a large extent in medical practices. With the exception of Brainware98, EPR systems directed towards South African use are not yet available in the market from which general practitioners can choose. As far as Brainware98 is concerned, concern has been expressed that South African physicians are not currently technically geared to fully utilise the system features. Although provision for x-ray images, for example, has been made, a x-ray scanner is necessary to utilise this facility. Very few physicians have this type of equipment, or are willing to make the capital investment in order to have one. A major part of the system would therefore probably not be utilised for at least the next few years, or until physicians become familiar with the latest available technology. The manual system discussed at the

beginning of this chapter is currently generally used for clinical notation in general practices.

In the following chapter the South African situation will be scrutinised even further. A questionnaire sent out to investigate the current state of the EPR in South Africa, and to determine the needs and requirements regarding such as system, will be discussed.

Chapter 4

Requirements Analysis

4.1 Introduction

Chapter 3 drew a picture of the current status of the EPR in South Africa. In order to prove the conclusions reached in Chapter 3, a requirements analysis was deemed inevitable. This requirements analysis was also necessary to gain a better understanding of the requirements, needs, and problems that general practitioners in South Africa experience regarding computer use, the notation of the clinical patient encounter, the handling of information in their practices, and their opinions on the EPR. As a result, a questionnaire was drawn up and sent to selected general practitioners. It is important to note that questionnaires have limitations. Users often find it difficult to articulate or recognise their information system needs when confronted with a questionnaire in comparison with being presented with a system or prototype. Although this method, therefore, is potentially biased, it was deemed to be the most appropriate method to apply in order to explore the barren field of the EPR in South Africa.

This chapter will discuss this questionnaire, its response as well as the interpretation thereof in depth.

4.2 Preparation of the questionnaire

The information gathered during the literature study, as was discussed in the three previous chapters, was used as a basis for preparing the questionnaire. The input of a physician associated with the Department of Family Medicine at the University of the Orange Free State, was continually sought as far as the content and completeness of the

questionnaire was concerned. Provision for Afrikaans and English respondents was made by preparing the questionnaire and associated cover letter in both languages. The content of the questionnaire will now be discussed (see Appendix A for the complete questionnaire).

The questionnaire was divided into four broad sections, namely section A to D. The questions in section A ensured that the respondent was a practising general practitioner, as the questionnaire was not intended to be completed by, for example, retired GPs or specialists. Section A continued to prompt the respondent as to the nature of the practice in which he/she was presently engaged (one-man practice/partnership/association), and for the number of years that he/she had been in private practice. Except for the cases where the respondent was not a practising GP, all the respondents had to complete all four sections.

Section B covered the use of computers in the physician's practice. If using a computer, the respondents were prompted for the purpose of the current use (administrative/clinical/other). They were requested to specify the medical commercial computer systems in use in their practices, as well as an indication of their satisfaction therewith, with reasons. Section B was concluded with a question to identify the current user of the computer, meaning the practitioner, the receptionist, or any other person associated with the practice.

The manual clinical record system, as discussed in Chapter 3, was covered by the questions in Section C. The respondents were asked to specify the components that their manual system consisted of (for example a file folder per patient, a clinical record card, etc.). They were requested to name the scheme they used to record clinical information (for example the SOAP-model), and to indicate whether notes were made in the presence of the patient. Although it was expected that the answers to the following question might be vague, an indication of how long it took to find and file a patient record was nevertheless requested. Additional purposes for which manual clinical records could be

used, for example to draw statistics, to create reminders, etc., was then addressed. Most importantly, the respondents were asked to specify the problems they experienced with the current manual system in use.

The crux of the questionnaire was included in section D. This section was further divided into:

- Use of the computer system
- Problems with/objections against computer-based patient records
- General.

Each of these three sub-sections will now be discussed briefly.

- **Use of the computer system** – The attitudes of the respondents towards the use of a computer in the presence of the patient during the consultation, was tested. The respondents were prompted for the most acceptable methods for entering information into the computer in the presence of the patient, as well as for identifying external parties with which contact would be required through the system. The issue of the requirement of a printed copy of an EPR, as well as whether the respondent was in favour of a guideline-based EPR system (see Chapter 2), was also included in this sub-section.

- **Problems with/objections against computer-based patient records** – This sub-section consisted of two questions, namely:

  - Which practical problems do you foresee regarding the use/functioning of an EPR system?
  - Indicate which problems you foresee with/objections you have against EPR records in general practice.

- **General** – The questionnaire concluded with six general questions which were deemed of the utmost importance to be able to draw a profile of possible future users of an EPR system. The contribution of professional societies regarding the EPR, the possible use of the Internet, the respondent's opinion regarding the possible success of an EPR system, whether he/she would use such a system if available, possible future participation in the research project, and the future use of a computer in the practice if not currently used, were covered.

The first version of the questionnaire was presented to personnel of the Department of Bio-Statistics at the University of the Orange Free State for their statistical input regarding the questions asked. Guidance was also received concerning the layout of the coding structures on the questionnaire as well as for the eventual coding of the questionnaire.

After adapting the questionnaire to all these changes, and presenting it for linguistic verification, the questionnaire was ready for a pilot test. This pilot test will now be explained.

4.3 Pilot test

In order to test the clarity and completeness of the questionnaire, copies were handed to ten general practitioners attending a course held by the Department of Family Medicine at the University of the Orange Free State. These ten "guinea-pigs" were selected to allow for none/minimum to vast computer experience. The feedback received from this trial was valuable for the finishing touches to ensure a clear and unambiguous questionnaire. A secondary advantage of the trial was the enthusiasm with which it was met by some of the trial respondents, and the positive attitude towards the basic principle of the EPR – a bonus that served as a welcome encouragement in the early stages of the research project.

The completed questionnaire was now ready to be sent out. Although it was clear that the target respondents were practising general practitioners, the question of whom to include

in the population still remained unanswered. This issue will be discussed in the following section.

4.4 Population

It was decided to use the Free State Province (a province roughly in the centre of the Republic of South Africa) as the population. The reasons for this decision were two-fold. First, the logistics of the exercise would be simplified if the respondents lived relatively close to where the research was undertaken. This would be especially helpful when the follow-ups were conducted. Secondly, and most importantly, it was believed that the needs in the Free State, and the way in which general practices are run in this province, should not differ substantially from the other provinces in the country. The logic behind this belief is that general practitioners in the Free State were not necessarily trained at the University of the Orange Free State. They come from all over the country, and in some cases, from other countries as well. Their medical backgrounds, therefore, differ substantially from one another. The same principle applies to the other provinces – they also have a mixture of general practitioners regarding background and experience. The variety of general practitioners in the Free State that will eventually be included in the sample, would therefore imply that the respondents would be representative of general practitioners in South Africa. For these reasons, it is important to note that all the conclusions reached in this thesis regarding general practices in the Free State, will be applied to the whole of South Africa.

In order to get the distribution of the questionnaires on the way, a list of all practising general practitioners in the Free State was requested from the South African Medical Council. Accompanied by a letter stating that the contents of the list would be used for the sole purpose of research, the request was granted. This list was then used as the population from which the sample was drawn. The sample will now be discussed.

4.5 Sample

A random sample of 150 was drawn from all the supposedly practising general practitioners in the Free State, as taken from the list supplied by the South African Medical Council. This sample (150) constituted 15% of the 995 physicians on the list. A cover letter was drawn up (Appendix A), self-addressed envelopes were printed, 150 copies of the questionnaire were made and labels of respondents' addresses were printed. Finally, these documents were assembled and sent off in January 1997. The respondents were given approximately one month in which to reply.

4.6 Response and follow-up

As soon as completed questionnaires were received, a problem appeared. It seemed that the list used to draw the sample from, was outdated. Of the original 150 questionnaires, 48 were returned by mid-February. This represented a response of 32%. Of the 48, however, only 37 responses could be used. The other 11 were irrelevant, because practitioners were either hospital appointments, had already retired or were specialising at that point in time. One envelope was returned to sender because of an unknown address. This reduced the response to 25%. These results are summarised in Table 4.1.

Status	Meaning	Number of questionnaires	% response from 150
1	Returned and usable	37	25%
2	Hospital appointments	6	
3	Retired	3	
4	Address unknown	1	
5	Specialising	1	
	TOTAL RECEIVED	48	32%

Table 4.1 Initial response to questionnaire sent out in January 1997

After telephone follow-ups in February and March 1997, 79 questionnaires in total were returned, of which 56 could be used (for the same reasons as mentioned above). Because 23 of the total of 79 questionnaires could not be classified as being the opinions of practising general practitioners, the original sample of 150 shrunk to 127. This brought the final response to 44%. In South African statistical circles a response of 30% is deemed to be good. The 44% final response was therefore more than satisfactory. It provided confidence in the validity and subsequent conclusions drawn from the questionnaire results. A summary of the final response is given in Table 4.2.

Status	Meaning	Number of questionnaires	% from 150	% from 127 (150–23)
1	Returned and usable	56	37%	44%
2	Hospital appointments	12		
3	Retired	8		
4	Address unknown	1		
5	Specialising	2		
	TOTAL RECEIVED	79	53%	62%

Table 4.2 Final response to questionnaire after telephonic follow-ups

4.7 Results

The questionnaires that had been received were coded according to a coding list prepared with the aid of the Department of Bio-Statistics. The coded questionnaires were handed to the above-mentioned department who processed the results with the aid of the SAS statistical computer program. At this point it is important to note that in some of the result tables that will follow, the figures overlap (do not add up to a 100%). The reason for this is that the respondents were allowed to choose more than one option in answering certain

questions. The results will now be discussed extensively in accordance with the four sections discussed earlier.

4.7.1 Section A – General Information

Fifty percent of the general practitioners who took part in the study indicated that they were engaged in a one-man practice, while the others were engaged in either a partnership or an association.

The maximum number of years spent in general practice was 47, while the mean was 6 years and the minimum 1 year. Table 4.3 shows the percentage of respondents who had been in general practice for the listed number of years.

NUMBER OF YEARS	%
1 – 5	41
6 – 10	29
11 – 15	12
16 – 20	12
21 – 25	4
26 – 30	2
31 – 35	4
36 +	2

Table 4.3 The number of years respondents spent in general practice

4.7.2 Section B – General Computer Information

A computer was used in 93% of the respondents' practices, while 7% had no computer technology available to assist them in their practices. Of those respondents using a computer, 100% used them for administrative purposes, 14% for dispensing, 12% for clinical purposes, and 8% for other purposes. Examples of these other purposes were electronic data interchange (EDI), VAT calculations, and stock control.

When asked to name the medical commercial computer system(s) currently in use, ten different systems were identified. The systems, as well as their frequency of use, are summarised in Table 4.4.

SYSTEM	% USE
Mass	37
Medsolve/Medsolve 2000	17
Medit	15
Multidoc	15
Trimed	4
Entremed: Trimed Program	4
Medix 3	4
Medrek	2
Medstat	2
Med-50	2

Table 4.4 Medical commercial systems currently in use in Free State general practices

Ninety-two percent of the respondents replied that they were satisfied with the system currently in use. The main reason given for the 8% not being satisfied with their systems, was that the systems were not integrated with clinical records. Other reasons were the non-integration with an accounting system, the system being user unfriendly, too many problems at month-end, no EDI connections, and finally that the system was too cumbersome.

Being recognised as a very important pre-condition for the success of EPRs, 67% of the respondents indicated that they *personally* used the computer system. Sixty five percent indicated that their receptionists used their systems, 60% that the systems were being used by clerical personnel, and 31% by an accountant. These results are summarised in Table 4.5.

CURRENT USER OF COMPUTER SYSTEM	% OF RESPONDENTS
Practitioner	67
Receptionist	65
Clerical personnel	60
Accountant	31
Lady in pharmacy	2
Spouse	2

Table 4.5 Current user of existing computer systems in general practices

4.7.3 Section C – Manual System

Regarding the current manual system in use in their practices, 63% indicated that they had a written task description/explanation of these systems, while 37% did not. As mentioned in Chapter 3, such a task description is deemed to be a very important aspect of clinical record systems [Pistorius 1986].

Table 4.6 summarises the "components" of the manual clinical record systems, as supplied by the respondents.

COMPONENT	% USE
File folder per household with individual family members' records inside	81
Specialist reports	81
Laboratory reports	79
Certificate of absence	77
Clinical record card	73
Prescription book only for prescriptions	63
Card with patient reference number	31
Problem list	21
Prescription book for prescriptions, house calls, hospital visits, operations	19
Cross referencing card (numerical reference numbers used)	19
File folder per patient	19
Other (e.g. letter of reference)	2

Table 4.6 "Components" of current manual clinical record systems

The SOAP-model (Subjective, Objective, Assessment, Plan) was the scheme used by 92% of the practitioners to record the clinical information, while the balance of 8% did not use a specific format. Similarly the "from head to toes" framework/scheme was used by 82% of the practitioners, while the other 18% also indicated that they did not use a specific format.

A very important aspect regarding the possible future success of the EPR was addressed by the question "*Which of the following usually applies to you when you record the clinical information of the patient?*". Table 4.7 shows that 60% of the respondents indicated that the notes were made in the presence of the patient, 35% that notes were made partly in the presence of the patient and partly as soon as he/she had left the room, 4% that notes were made as soon as the patient had left the consulting rooms, and 2% that notes were made at the end of each day.

CURRENT NOTATION METHOD OF CLINICAL INFORMATION	% OF RESPONDENTS
Notes were made in the presence of the patient	60
Notes were made partly in the presence of the patient and partly as soon as he/she had left the room	35
Notes were made as soon as the patient had left the consultation rooms	4
Notes were made at the end of each day	2

Table 4.7 Current notation method of clinical information

The duration (in seconds) to find a patient record in the manual system varied from 2 seconds to 210 seconds, as can be seen on Table 4.8. The "most popular" (mode) duration specified, was that of 30 seconds (29% of the respondents). Eleven respondents refrained from answering the question. Similarly, Table 4.9 shows the duration (also in seconds) to file a patient record. This varied from 2 to 180 seconds, of which 60 seconds was the most popular choice (23% of the respondents). Here 13 respondents did not answer the question.

APPROXIMATE DURATION (SECONDS) TO FIND A MANUAL RECORD	% OF RESPONDENTS
2	2
5	2
10	22
15	7
20	4
30	29
60	20
90	2
120	7
150	2
210	2

Table 4.8 The approximate time (in seconds) to find a manual patient record

APPROXIMATE DURATION (SECONDS) TO FILE A MANUAL RECORD	% OF RESPONDENTS
2	5
5	2
10	21
15	7
20	9
30	21
45	2
60	23
100	2
120	5
180	2

Table 4.9 The approximate time (in seconds) to file a manual patient record

In addressing the problems that general practitioners experience with their current manual systems (which are also the aspects that an EPR should attempt to resolve), the problems in Table 4.10 were highlighted.

PROBLEMS	% OF RESPONDENTS
Mis-filed files	62
Recording of external work	46
Separate clinical & financial systems	42
Time consuming	35
Lost files	33
Identifying old, unused records	31
Incompleteness of medical record as a whole	29
Durability of records	25
Transferability of records	23
Filing reports/x-rays	21
Delays in handling specialist/lab reports	21
Duplication	14
Illegible/incomprehensible	12
Immediate recording of patient' visit	10
Not adaptable to changing circumstances	10
Unpractical format	8
Disorganised, files become too thick, storage of files becomes problem	6

Table 4.10 Problems associated with current manual systems

Additional purposes for which existing clinical manual records are used (Table 4.11), include the drawing of statistics for personal information and for the sake of interest (27%), reminders of follow-up visits (20%), determining health risks, e.g. to determine a patient's chance of having a heart attack (16%) and research regarding general practice (6%). It is interesting to note, however, that 54% indicated that they are unable to utilise their clinical records in any way.

ADDITIONAL PURPOSES OF EXISTING MANUAL CLINICAL RECORDS	% OF RESPONDENTS
Draw statistics for personal information and for the sake of interest	27
Reminders of follow-up visits	20
Determining of health risks e.g. to determine a patient's chances of having a heart attack	16
Research regarding general practice	6
Self-monitoring of patient care & progress as a result of medication	2

Table 4.11 Additional purposes that existing manual clinical records can be used for

4.7.4 Section D

As mentioned before, this section was divided into three sub-sections. The response to the questions in each of these sub-sections will now be summarised.

- **Use of the computer system**

Fifty five percent of the respondents indicated that they would still prefer to have a printed copy of their patient's record, should they change to an electronic patient record system. The major reasons for this were the necessity of paper copies for reports (50%), the need for a paper copy as a result of habit (50%), the need for a backup for the computer system (43%) and the convenience of having everything close-by and to have a paper copy for reference purposes.

The 45% who indicated that they do not see a need for a printed copy of the patient record, reasoned that costs would be unnecessarily increased (56%), that a printed copy should only be available on request only (22%), and that a paper copy would necessitate an extra filing system (6%).

Asked about their attitudes towards the use of a computer in the presence of the patient during the consultation, the response varied with the majority (27%) feeling neutral about it, 25% being totally positive, 23% being moderately positive, 16% being moderately negative, and only 9% being totally negative (Table 4.12). Those respondents feeling totally or moderately negative about using the computer in the presence of the patient during the consultation, are convinced that the patient should have the undivided attention of the practitioner, that the patient might feel like a number on a piece of paper (impersonal), and that the practitioner will still keep paper notes. They are also concerned that the patient might behave in a peculiar fashion, for example by jumping to his/her feet and walking around the desk to see what the physician is doing on the computer screen.

ATTITUDE TOWARDS USING A COMPUTER IN THE PRESENCE OF THE PATIENT	% OF RESPONDENTS
Totally negative	9
Moderately negative	16
Neutral	27
Moderately positive	23
Totally positive	25

Table 4.12 Attitudes towards using the computer in the presence of the patient

The moderately or totally positive inclined respondents reason that it is disruptive to write in the presence of a patient anyway, and that the EPR seems to be quick, correct and organised. The fact that everything (consultation, account) is concluded by the time the patient leaves the consulting room, is deemed a welcome thought, as well as the notion that the EPR will demonstrate the thoroughness of the practitioner. The constant availability of the records is also a plus point. Despite their positive attitudes, it is seen as a pre-requisite that the physician should have the confidence to use a computer in the presence of a patient and that the patient should have the physician's undivided attention.

In addition to reasons already stated, the neutrally inclined motivate their attitude by cautioning that the EPR might be time consuming, that problems might occur as a result of under-developed typing skills of physicians, and that success will vary from patient to patient. It was also mentioned that the computer is already being used in the presence of patients, and with great success.

Being asked in which instances the computer could be used with success in the presence of a patient, calling up a patient's medical record got the best support (86%), followed by dispensing (73%), administrative /financial applications (71%), part of the clinical examination (46%), and for statistical/graphical information (29%). These results are summarised in Table 4.13.

INSTANCES WHERE THE COMPUTER CAN BE USED IN THE PRESENCE OF THE PATIENT	% OF RESPONDENTS
Call up a patient's medical history	86
Dispensing	73
Administrative/Financial	71
As part of the clinical examination	46
Statistical/Graphical information	29
None	2

Table 4.13 Instances where the computer can be used in the presence of the patient

Regarding the question of the preferred methods for entering information into the computer in the presence of the patient (Table 4.14), using the mouse was the most popular (50%). This was followed by typing from the keyboard (44%), speech (33%), a touch screen (24%) and a bar code scanner (also called a light pen) (9%).

METHODS FOR ENTERING INFORMATION INTO THE COMPUTER	% OF RESPONDENTS
Mouse	50
Typing, using the keyboard	44
Speech	33
Touch screen	24
Light pen (pen-size type of bar code scanner)	9
Light pen on board in desk	2
None	2

Table 4.14 Methods for entering information into the computer in the presence of the patient

In the case where a computer system is to be used during the clinical examination (Table 4.15), 66% of the physicians preferred to enter the information immediately in the presence of the patient. Twenty one percent preferred to make notes which they would enter into the computer later on, while 4% preferred to make notes which the

receptionist/clerical personnel could enter at a later stage. Two percent felt that the best way for them would be to enter the information via speech recognition technologies.

METHODS PREFERRED IF A COMPUTER SYSTEM WAS USED DURING THE CLINICAL EXAMINATION	% OF RESPONDENTS
Enter the information immediately in the presence of the patient	66
Make notes which you will enter into the computer yourself later on	21
Make notes which the receptionist/clerical personnel can enter later on	4
None of these methods	5
Entering the information using speech recognition	2
Enter the information yourself directly after the consultation	2

Table 4.15 Methods preferred if a computer system was used during the clinical examination

With the computer forming part of the clinical examination, the respondents were prompted for possible utilisation of the results and output of an EPR system (Table 4.16). The majority of the respondents (93%) deemed ordered computerised text-based patient records as the most important EPR output. Issuing prescriptions were next in line (74%), followed by images (for example a photograph of the patient or X/rays) with 41%, planning information (39%), access to external health databases (39%), and statistics and graphs (37%). Only 15% voted for research purposes.

POSSIBLE UTILISATION OF SYSTEM RESULTS AND OUTPUT	% OF RESPONDENTS
Organised computerised text-based patient records	93
Prescriptions	74
Images, e.g. photograph of patient, x-rays	41
Information for planning purposes	39
Access to external (health services) databases	39
Statistical information/graphics regarding individual/all patients	37
Information for research purposes	15
None of these options	4
Internet	2

Table 4.16 Possible utilisation of system results and output

One of the known advantages of EPRs is better communication among the health services. Response to the question asking with which parties the physician would like to establish contact through the system (Table 4.17), indicated that pathologists and medical funds were the most popular choice (both 82%), with specialists and laboratories following closely behind (73%). Radiologists (66%), other general practitioners and pharmacies (both 47%), and hospitals (36%) also received support. Suppliers of stock, emergency services (e.g. poison centres), and central databases received the support of 6% of the respondents.

PARTIES WITH WHOM CONTACT THROUGH THE SYSTEM IS REQUIRED	% OF RESPONDENTS
Pathologists	82
Medical funds	82
Other specialists	73
Laboratories	73
Radiologists	66
Other general practitioners	47
Pharmacies	47
Hospitals	36
Suppliers, emergency services, and central databases	6
None of these parties	6

Table 4.17 Parties with whom contact through the system is required

Addressing the important aspect of the data model used for designing an EPR system, the following question was put to the respondents: "*Are you in favour of a guideline-based computerised patient record system, i.e. a system based on systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances?*". A substantial number of respondents, namely 78% indicated that they were in favour thereof, while 22% indicated that they weren't. Six respondents did not answer the question, which might indicate that they did not understand the question or that the principle was foreign to

them. This poses the question whether the 78% did indeed understand the question and as a result, one could query the validity of their response.

- **Problems with/objections against computer-based patient records**

One would not get an objective view of the opinions of general practitioners regarding the EPR if one did not dare ask what problems/objections they foresaw regarding the use/functioning of such a system, as well as with its use in general practice. Tables 4.18 and 4.19 represent the responses to these two questions.

PROBLEMS FORESEEN WITH USE/FUNCTIONING OF THE EPR	% OF TOTAL
Recording of work performed outside the consulting room	56
Problems in linking information (e.g. hand-written reports) with system	56
Relationship of trust with the patient	42
Process of change from a manual system	42
Computer tasks interfering with existing normal tasks	42
Immediate recording of a visit	31
Lack of general standards regarding standard clinical vocabulary	22
Resistance on the part of the patients	15
Changed working method	15
Lack of general standards regarding patient identification	7
Not adaptable to changing circumstances	4
Power failures in the country side and viruses	4

Table 4.18 Problems foreseen regarding the use/functioning of a computer-based patient record system

Table 4.18 indicates that the recording of work performed outside the consulting room and problems with linking information, are the major concerns regarding the use/functioning of an EPR. As far as the foreseen problems in general practice are concerned, Table 4.19 indicates that the initial capital investment and the duration of the patient encounter are the two main concerns.

PROBLEMS FORESEEN WITH THE COMPUTER-BASED RECORD IN GENERAL PRACTICE	% OF TOTAL
Cost : Initial capital investment	61
Time : Duration of patient encounter	55
Computer illiteracy	46
Time : Training	43
Security	43
Time : Use of the system	34
Software	32
Ethics	29
Hardware	27
Cost : Operating cost	20
Quality of information	18
Personnel	16
Lost information, linking with other institutions	5
None of the above	2

Table 4.19 Problems foreseen with/objections against computer-based patient records in general practice

- **General**

The questionnaire concluded with a few general EPR-related questions that, among other things, prompted the respondents for the possible success/failure of the use of electronic medical records in general practice.

CONTRIBUTION OF PROFESSIONAL SOCIETIES	% OF RESPONDENTS
Provision of guidelines for information systems in general practice	64
Training of general practitioners in the use of information systems	58
Evaluation of existing computer systems	56
Negotiating partial compensation for system implementation with government	56
None of the above	2

Table 4.20 Desired contribution of professional societies

Asked to which fields professional societies should contribute (Table 4.20), 64% of the respondents felt that provision of guidelines for information systems in general

practice was most important. This was followed by training of general practitioners in the use of information systems (58%), evaluation of existing computer systems (56%), and negotiating partial compensation for system implementation with government (56%).

The Internet was also addressed in the questionnaire. Seventy three percent of the practitioners showed an interest in using the Internet, while 27% were not interested at all, reasons varying from lack of time, not important for good practising methods, lack of knowledge regarding the Internet, to high costs. Those in favour of using the Internet, motivated their opinion with the fact that it opens an immediate "gateway" to international medicine. It was also stated that the Internet was crucial to ensure that the South African medical profession does not lag behind because of our third world status. It was no surprise to find that those practitioners in favour of the Internet eventually indicated that they were in favour of the EPR concept as well. The results, however, might have been more meaningful if a question regarding the actual current use of the Internet had been included.

The two most critical questions of the questionnaire were: "*Are you of the opinion that a computerised patient record system can be successful?*", and "*If a good computerised patient record system were to be available, would you use it?*". In answer to the first question, 91% were of the opinion that it can be successful, while 9% believed the contrary. The negative response was motivated mainly by a fear of the influence of computer illiteracy. Quite a number of reasons were given for giving the EPR a fair chance on success. The most important reasons were that the EPR is more organised, that success will depend on the software and operators, that the record will always be available, and that the implementation of the EPR will ease general practice keeping.

The response to whether or not they would use an EPR system, if available, varied from 91% who replied positively, to 9% who declined. The positive reply was,

however, dependent on time and cost of implementation, and whether or not the system would be available on a network. Another pre-requisite mentioned was that it will be utilised if health, financial, and medical fund aspects were to be combined. Reasons for not being willing to use such as system, varied from the cost aspects, the opinion that an EPR is unnecessary, to the statement that it will not be feasible in all types of practices.

Prompted for their willingness to participate in the research project in future, 89% replied positively. The last question asked whether the practitioner would like to use a computer in his/her practice in future if not doing so at present. Of the 7% to which this question was applicable, 5% indicated that they would like to computerise in future. The reason given for the 2% who would not consider computerisation, was that the staff threatened to walk out should computers be brought into the practice!

In the following section an attempt will be made to interpret the above-mentioned results.

4.8 Interpretation and discussion of results

Given a response of 44%, one might argue that the questionnaire was completed by general practitioners who are positively inclined towards computers. Those who do not like computers, who are computer illiterate or who are sceptical about the use of computers in general practice, most probably constitute a substantial percentage of the 56% practitioners who did not respond. Considering the distribution regarding the number of years in general practice, most of the respondents are relatively young (mean of 6 years). These facts might indicate that the results of the processed questionnaires will be slightly biased towards computer-use. Of the 56 respondents, only 4 do not use a computer in their practices at all.

The sample is, however, well represented as far as the nature of the practices (one-man practice or partnership/association) is concerned. It is interesting to note that 50% of the respondents have urban practices, while 50% have rural practices.

The results show that computer use in general practice in the Free State is limited to administrative purposes. The majority of commercial medical computer systems mentioned, constitute administrative and/or financial functions. The lack of integration with clinical records is therefore also one of the reasons given for not being satisfied with the computer system currently in use. Only 6% of the respondents indicated that their systems are used for clinical purposes as well. All this shows that the design and implementation of EPR systems in the Free State, and probably in South Africa, is a barren field with a lot of potential to explore.

To be successful, popular belief states that it is crucial that the practitioner will personally use an EPR system. The fact that 67% of the respondents indicated that that was the case with their current computer systems, may be a positive indication regarding the attitudes, willingness, and computer literacy of general practitioners, which will be very important when implementing an EPR system.

The response to the "components" that form part of the currently-used manual clinical record systems, implies that the majority of the physicians follow the guidelines for manual systems as described in Chapter 3. This is the reason why the manual system was used as a starting point for designing the first prototype EPR system. It is similarly significant that the SOAP-model and the "from head to toes" framework are used by respectively 92% and 82% of the respondents.

Using their current manual clinical record systems, 60% of the practitioners indicated that they take notes in the presence of their patients. Although there might still be some controversy surrounding this issue, the conclusion can be made that this method would be preferable when using an EPR system as well. Whether one is writing, or typing/making

choices on a computer, one is still momentarily distracted from the patient. Where 35% of the respondents indicated that notes are made partly in the presence of the patient, and partly after he/she has left the room, the same can be done with an EPR system. The exclusion of an option to allow the patient to enter the data may be viewed as an example of the biased nature of questionnaires.

The two questions regarding the duration of finding and filing a paper patient record, might be viewed as insignificant as most respondents probably handled it as a "thumb-sucking" exercise. It might, however, become more meaningful when comparing the results when the same tasks can be physically measured using an EPR system.

It is interesting to note the similarity in the problems that the respondents experience with their current manual systems, to the problems stated elsewhere in the world, as mentioned in Chapter 1. One of the major disadvantages of manual patient records is also highlighted by the lack of additional purposes to which these records can be applied. Computers, on the contrary, are excellent tools to accomplish most of the possible additional purposes, namely the drawing of statistics, the printing of reminders for follow-up visits, the determination of health risks, and research. Although not specifically mentioned in the questionnaire, the results of EPRs may additionally be utilised in, e.g. MEDLINE and in textbooks.

The majority of attitudes towards using a computer in the presence of a patient being neutral, moderately positive or totally positive, can be interpreted as a go-ahead in designing an EPR system. It should, however, be born in mind that the system should be designed in such a way that the practitioner will still be able to make the patient feel as if he/she is the most important person in the consulting room. The computer system should complement the consultation, rather than dictate the consultation.

There is scepticism among practitioners regarding the use of a computer in the presence of the patient. This was illustrated by the response of only 46% towards using the computer

as part of the clinical examination. This might be because of fear of the unknown. Practitioners do not seem to have any problem with using the computer in the presence of the patient to call up a medical record, for dispensing, or for administration/financial applications. When given a situation where a computer is used as part of the clinical examination, it is positive to note that the practitioners would prefer to enter the information immediately in the presence of the patient, as is the case with the use of their current manual systems.

Based on the response received on the matter, communication channels with other health professionals, especially with pathologists, medical funds, specialists, laboratories, and radiologists, is a must in any EPR system. Communication with patients (e.g. via e-mail) has been excluded as an option from the questionnaire and should be viewed as a limitation.

Considering user interface aspects, it is interesting to note that practitioners prefer using a mouse and the keyboard. This would indicate a graphical user interface. There is, however, concern regarding the lack of typing skills, and this should be taken into account. As a result the prospective system should be designed in such a way that the duration of the patient encounter would not considerably be influenced by it.

Practitioners do foresee problems with the use/functioning of EPRs. Their main concerns revolve around practical implementation problems in changing from a manual to a computer system. Recording of work performed outside the consulting room, problems in linking e.g. hand-written reports with the system, and the possible influence on the relationship of trust with the patient, are three main concerns indicated regarding the use and functioning of an EPR system. These are valid concerns, but not without solutions. It is always useful to be reminded of how a certain task was handled in the manual system. In the case of outside work, for instance, the recording was done on the back of the prescription book. The next morning the information would then be added to the patient file. There are no valid reasons why the same principle cannot be followed with an EPR system. The notes can be transferred to the computer the next morning. Similarly the

essential aspects of hand-written reports can be underlined by the physician (as was being done in the manual system set-up) and be entered into the electronic version of the patient record at a later stage, either by the physician, or by the receptionist. The original report can be filed as usual for a more detailed reference, if required. The relationship of trust with the patient will depend greatly on the manner in which the physician handles the consultation. It is true that the introduction of an EPR system into a practice will necessitate changes, especially in the mindset of the physician. When taking the patient into his/her confidence as far as the changes brought about with the introduction of a computer is concerned, the patient should theoretically trust the physician with his/her clinical information in the same way as he/she was trusted with a paper version thereof. Just as the physician would, for example, look the patient straight in the eye while listening to the main complaints before starting to write the note, he/she should refrain from using the computer during that stage of the consultation. This will build confidence and allow the physician to be sensitive to certain aspects betrayed by the patient's body language.

The main concern regarding EPRs in general practice, lies in the initial capital investment. This is a very important point, especially when considering the type of computer system to develop. In order for a computer system to be successful, it should be used, and therefore should be affordable to the average general practitioner. In comparison with other countries, like the Netherlands, the chances of professional societies in South Africa negotiating partial compensation for EPR system implementation with government, are bleak. No financial assistance should therefore be expected from that area.

This brings us to a very important consideration: Should one buy an existing EPR system and adapt it to South African circumstances (if possible!), or should one develop a system "from scratch"? As was mentioned earlier, no generally known and accepted EPR system exists in South Africa, as evidenced by the results of the questionnaire. Purchasing an existing system would imply purchasing an overseas product. The main problems (difficulties) regarding overseas products from a South African perspective include the difference in the funding mechanisms for health care in South Africa, the difference in

general practice style, and the GPs relationship to hospitals, specialists, pharmacists, and pathologists. Additionally, the present exchange rate and the present economic situation in South Africa, as well as taking into account that one has to provide for a third world country, would make it extremely difficult (if not impossible) to find a system to fulfil the requirements while still being affordable to South African GPs in general. Another consideration, as was illustrated in Chapter 2 with some of the existing overseas products that were investigated, is that these products provide the user with Utopia – all the latest (and often expensive) technology. In a country like South Africa it might be more feasible to start with the basics and gradually add to it, as the circumstances permit or require.

Ninety one percent of the respondents were of the opinion that an EPR could be successful, and that they would use such as system, if it was available. This, in conjunction with the above-mentioned facts, was interpreted as enough motivation to start the daunting task of designing such a prototype system.

4.9 Summary

In this chapter, the process of conducting the requirements analysis was discussed. Questionnaires were sent out to practising general practitioners to mainly determine whether a need for an EPR system in South Africa existed, and if it did what the requirements would be. The response to the questionnaire gave exactly that.

The results of the questionnaires indicated that general practitioners in South Africa realised the need for implementing computers in their practices. As is the case in many parts of the world, they do experience frustrating problems with their current manual systems. The computer systems currently used in general practice mainly focus on administrative duties, and there is a need to integrate these functions with clinical EPRs.

NEEDS AND REQUIREMENTS
A printed copy of the patient record should be provided in addition to the record on the computer screen
The EPR should be easy enough to use to allow the physician to give the patient the attention he/she deserves
It should be possible to retrieve (and create) a medical record in the presence of the patient
Dispensing should be possible
The EPR should have a "usable" graphical user interface
Information should be entered with the aid of the mouse and keyboard
The most important "utility result" of the EPR should be a well-organised text-based patient record (images where appropriate)
A printing facility to print notes, reminders, reports, etc. should exist
Electronic communication with e.g. pathologists, medical funds, specialists, laboratories, and radiologists should be possible
Electronic communication (via e-mail) with patients should be possible
It should be possible to record work performed outside the consulting room (e.g. house calls) in the EPR
Hand-written reports should be linked with the EPR
The EPR should be affordable
The duration of the patient encounter using the EPR should not be considerably longer than with the manual system
Computer illiteracy should be born in mind (limit typing)
The EPR should require a short training time (easy to learn)
The EPR should be secure and available
The EPR should function on a network as well
Financial and administrative information should be integrated with the clinical information via coding schemes

Table 4.21 A summary of the needs and requirements regarding the EPR in SA

The practitioners indicated that the type of system they would consider implementing, should be graphically based, using the mouse and keyboard for entering data (and in future, possibly voice). It should be able to handle images and prescriptions, and facilitate communication to various other roll players in the health industry. Despite the fact that there is concern regarding the patient not getting the practitioner's undivided attention,

most practitioners felt that they would be able to use the computer in the presence of the patient. They would also prefer to enter the clinical information *immediately* in the presence of the patient. The practitioners are also willing to use the computer systems *personally*, an aspect which is considered to be of the utmost importance for the success of the EPR. Table 4.21 presents a summary of the needs and requirements regarding the (South African) EPR as identified in this chapter.

Despite some problems that are foreseen, a clear impression was left that general practitioners believe in the concept of the EPR, that they definitely feel a need for it and that they would use it, when available. This triggered the next phase of the research project, namely progressing towards designing an EPR prototype system to try and fulfil the needs of general practitioners in South Africa. The first prototype EPR system will be presented and discussed in Chapter 5.

Chapter 5

First EPR Prototype

5.1 Introduction

Chapter 4 provided guidelines of what general practitioners in South Africa require from an EPR system. With that as a foundation to start from, the task of designing and developing a first prototype system could now be undertaken.

In this chapter the choice of development environment, the database[5] design, and interface issues will be explained. The prototype will then be discussed with the aid of screen printouts. Special care will be taken to illustrate how the physicians' requirements, as discussed in the previous chapter, have been incorporated in the design. The chapter will be concluded with an explanation of the evaluation procedure and evaluation results of this first prototype.

The development environment and motivation for deciding on it, will now be discussed.

5.2 Development environment

It was decided to develop the first prototype system in a Windows environment in Borland C++ Builder. The Department of Computer Science and Informatics at the University of the Orange Free State, from where the research project was undertaken, standardised on this environment a few years ago. This meant that the software was available and that the

[5] A database is a shared , integrated computer structure that houses a collection of:
- End user data - that is, raw facts of interest to the end user
- Metadata, or "data about data", through which the data is integrated [Rob 1997].

hardware in use would be able to handle the software requirements. C++Builder also compiles relatively fast and creates an executable file. An executable file implies that the resultant application can be installed on a computer without C++Builder being present on that machine. This, in conjunction with the fact that C++ Builder provided a graphical, object oriented[6], Rapid Application Development (RAD)[7] environment, made it an obvious choice.

Borland's database engine gives the user the opportunity to choose the table type when creating a new database. The choices vary from Paradox, Visual dBASE, dBASE, INTRBASE, FOXPRO, and MSACCESS. It was decided to use the default, namely Paradox 7 database tables. In the next section the database design will be explained.

5.3 Database design

In Chapter 2 the three basic models that have been developed for computerised medical records, namely the template model, the Hindsighted Practice Guideline Model, and the Foresighted Practice Guideline Model, were discussed.

The template model is by far the most popular model and the one the medical personnel involved in the study understood best and preferred. This model implies fixed database fields with fixed lengths, as well as fields making provision for free text. Many of the general practitioners responding to the questionnaire discussed in Chapter 3, indicated that they preferred a free-text format where they have the freedom to enter narrative into memo fields. They were adamant that they would not like to be limited or restricted, or forced to make a specific diagnosis.

[6] Object oriented programs are constructed from a set of entities called objects. An object is an abstract representation of a real-world entity that has a unique identity, embedded properties and the ability to interact with other objects and itself. These objects interact with each other through events to solve a problem [Rob 1997].

[7] RAD makes it possible to build a program quickly through the use of a visual environment and standard components, which are "pre-packaged" objects, or sets of objects.

From a computer science point of view, using free text fields in abundance is not practical, as it makes tasks such as obtaining statistics extremely difficult, if not impossible. The challenge, when using the template model for the first prototype, seemed to be the daunting task of finding the golden midway between two extremes, namely a fixed format and a free-text format.

Before the specific database design of the first prototype will be discussed, a brief background discussion regarding database models may be appropriate. Section 5.3 will therefore proceed with a brief introduction to database models, with specific mention of the models used in the design of the first prototype's database. It will be followed by the entities[8], relationships between entities, the Entity Relationship (E-R) model and the attributes[9] of the mentioned entities of the first prototype. At this stage it is important to note that the approach followed in this chapter regarding database design constitutes one of many possible alternative approaches.

5.3.1 Brief introduction to database models

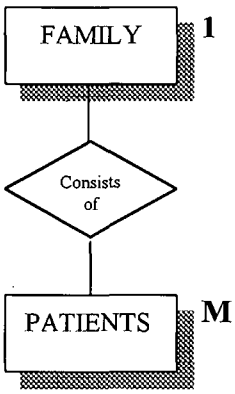
A database model is a collection of logical constructs used to represent the data structure and the data relationships found within the database. Database models can be grouped into two categories: *conceptual* models and *implementation* models. The conceptual model focuses on the logical nature of the data representation. Therefore, the focus is on *what* is represented in the database, rather than *how* it is represented [Rob 1997].

Conceptual models use three types of relationships to describe associations among data, namely one-to-many, many-to-many, and one-to-one relationships. Each of these relationships will now be explained with the aid of an example.

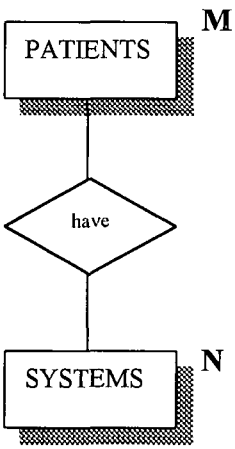
- **One-to-many relationship** – A family might consist of many different patients, but each patient can only belong to one family. Therefore a family (the "one") is related to

[8] An entity is a person, place or thing for which data is to be collected and stored [Rob 1997].

the patients (the "many"). The one-to-many relationship is labelled "1:M" and can be represented by the following illustration:

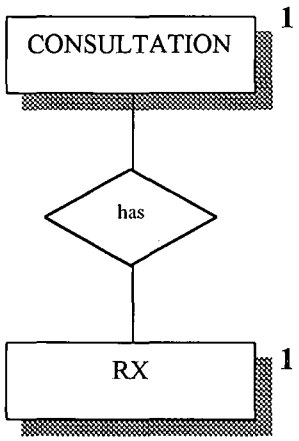


- **Many-to-many relationship** – A patient might have information on all fourteen body systems and each body system might be applicable to many patients. The many-to-many relationship is labelled "M:N" and can be represented by the following illustration:



- **One-to-one relationship** – Per consultation, a patient can only have one Rx (therapeutic measures e.g. prescription, operation) record. Each specific Rx record therefore belongs to a specific patient. The one-to-one relationship is labelled "1:1" and can be represented by the following illustration:

[9] Each entity has certain characteristics known as attributes [Rob 1997].



Conceptual models include the Entity-Relationship (E-R) model and the Object Oriented (OO) model. According to Rob and Coronel [Rob 1997], the E-R model is a widely accepted tool that is commonly used to:

- Translate different views of data among managers, users, and programmers to fit into a common framework
- Define data processing and constraint requirements to help meet different views
- Help implement the database.

The E-R diagram or ERD is used to map the E-R model. The following symbols are used in constructing an E-R diagram [Rob 1997]:

- Rectangles are used to represent entities
- Diamonds are used to represent the relationship(s) between the entities
- The number 1 is used to represent the "1" side of the relationship
- The letter M is used to represent the "many" side of the relationship. If a "many to many" relationship is to be indicated, the letters M and N are used.

The OO model, in contrast to the E-R model, is based on object-oriented concepts, as briefly explained earlier in the chapter. The E-R model was chosen as the conceptual

model for the first prototype and will be discussed in more detail in section 5.3.4. Therefore, for the purpose of this thesis, the OO Model will not be discussed further.

In contrast to a conceptual model, an implementation model places the emphasis on *how* the data is represented in the database, or on how the data structures are implemented to represent what is modelled. Implementation models include the hierarchical database model, the network model, and the relational database model. The relational database model is preferred over its two predecessors for a number of reasons. The most important reasons are its ease of use, the fact that the database structure is of no interest to users and designers, and its very powerful and flexible query capability through the Structured Query Language (SQL)[10].

In section 5.3.2 the reader will be presented with the entities that have been identified for the first prototype.

5.3.2 Entities

The entity at the E-R modelling level corresponds to a *table*. A specific entity instance is referred to as a *row*.

The entities that have been identified for the first EPR prototype system are presented in Table 5.1. The entities are listed alphabetically.

In section 5.3.3 the different relationships between the above-mentioned entities will be discussed.

[10] SQL makes pure ad hoc queries a reality. It is a fourth-generation language (4GL) as it allows the user to specify what must be done without specifying how it must be done [Rob 1997].

ENTITY	DESCRIPTION
CONSULT	Consultation per patient
DX	Diagnostic measures, e.g. E.C.G. investigation
FAMILIES	Family demographic information
GAPPEAR	General appearance information per patient per consultation
GATSKE	Six measures for general appearance
HISTORY	Medical history per patient (family history and general profile)
HISTSYS	Systemic history information per patient
LANGUAGE	Lookup table for possible different languages
MARITAL	Lookup table for possible marital states
MEDFUNDS	Lookup table for possible medical funds (aids)
NATURE	Lookup table for the different natures of a consultation, e.g. consultation, housecall, operation
PALLERGY	Allergies listed per patient
PATIENTS	Patient demographic information
PCX	Patient counselling/information and follow-up consultations
PDX	Patient diagnostic measures, e.g. E.C.G. investigation
PREVEXAM	Previous investigations per patient
PREVILL	Previous illnesses per patient
PREVINJU	Previous injuries per patient
PREVMEDI	Previous medications prescribed per patient
PREVOPS	Previous operations per patient
PROBLEMS	Problems for the problem list per patient
PRX	Therapeutic measures, e.g. prescription, operation
RELATE	Lookup table for possible relationships among patients
SREXAMINATIONS	Lookup table for possible sideroom investigations
SROOMEXAM	Sideroom investigations per patient per consultation
SYSINQ	Systemic examination per patient per consultation
SYSTEMS	Lookup table for possible systems in the human body
TITLES	Lookup table for possible titles of patients

Table 5.1 Entities identified for the first EPR prototype

5.3.3 Relationships

A relationship is an association between entities. Each relationship is identified so that its name is descriptive of the relationship. Ideally, the relationship name is an active verb, but passive verbs are acceptable.

In addition to the symbols used to construct an E-R diagram, as mentioned in section 5.3.1, two relationship terms, namely *connectivity* and *cardinality* need clarification.

- **Connectivity** – This term is used to describe the relationship classification, namely one-to-one, one-to-many, and many-to-many. As mentioned earlier, the E-R diagram indicates the relationship connectivity by placing a 1, M, or N near the related entities.
- **Cardinality** – This term expresses the specific number of entity occurrences associated with one occurrence of the related entity. The cardinality is indicated by placing the appropriate numbers in brackets beside the entities.

Before taking a closer look at the specific relationships for the first EPR prototype, it is important to note that the relational model requires the use of 1:M relationships instead of M:N relationships. If M:N relationships are encountered, a bridge must be created between the entities that display such a relationship. The bridge is an entity composed of the primary keys of each of the entries to be connected. (In general terms a primary key is an attribute, or combination of attributes, that uniquely identifies any given entity (row)). This bridge entity is called a composite entity. A composite entity is indicated by drawing a square around the diamond that presents a relationship between the two entities [Rob 1997].

The detail relationships that exist among the different entities are presented in E-R diagrams in Appendix B. As an example, however, the Patient – Consultation relationship will be given in Figure 5.1.

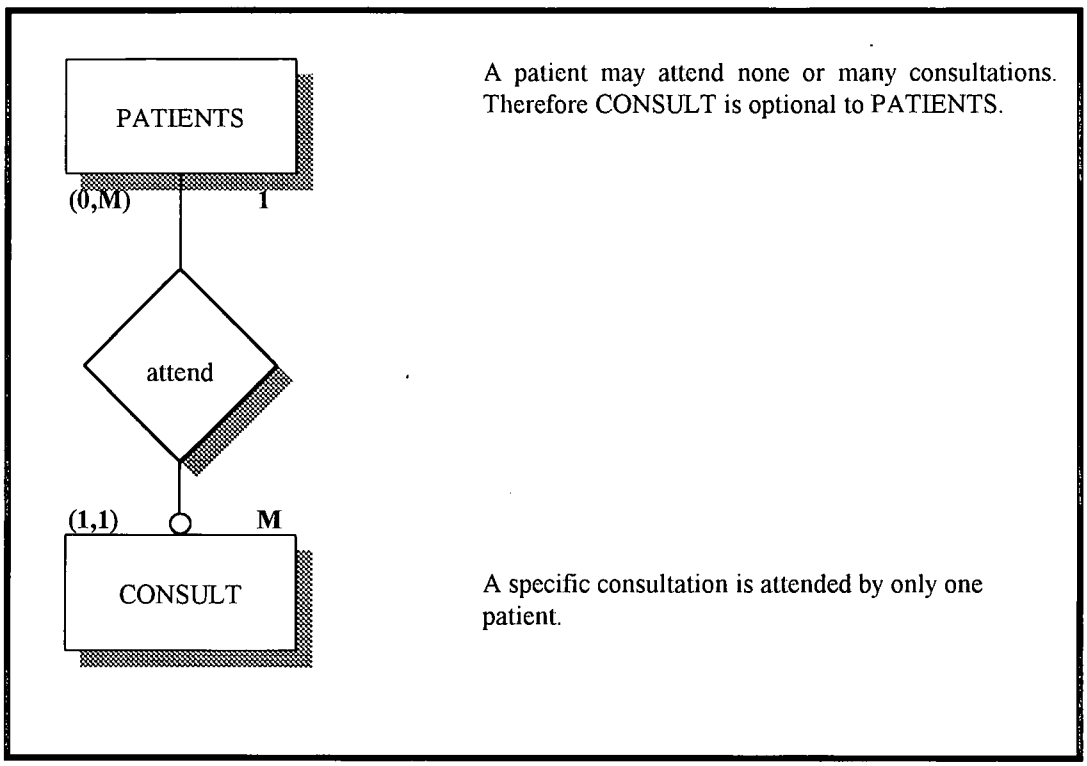


Fig. 5.1 E-R diagram presenting the Patients and Consultations relationships

The complete E-R diagram will be shown in the following section.

5.3.4 The Entity Relationship (E-R) model

Figure 5.2 illustrates the complete E-R diagram where all the relationships illustrated in Appendix B are combined into one diagram.

5.3.5 Attributes

As mentioned before each entity has certain characteristics, better known as attributes. Each attribute should be named appropriately to remind the user of its contents. All attributes have a domain, which is the attribute's set of possible values.

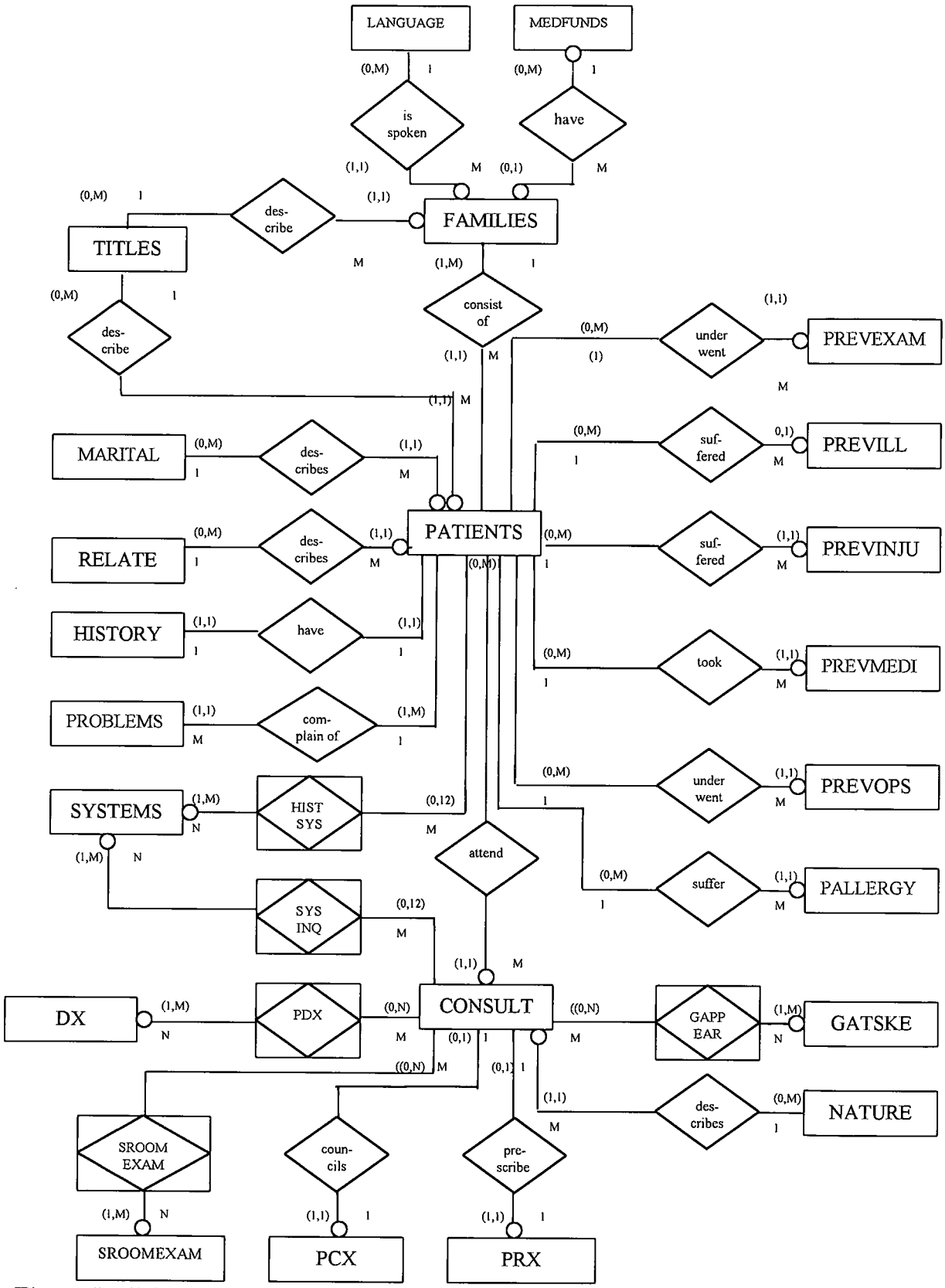


Figure 5.2 E-R Diagram of the First Prototype

In this section, as an example, the attributes of the first entity, namely CONSULT, will be summarised in tabular form (Table 5.2). The attributes of CONSULT will be presented in E-R diagram format (Figure 5.3), followed by sample data (Table 5.3). The attributes for the rest of the entities can be seen in Appendix C, while sample data for these entities are given in Appendix D.

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Con_ConsultId	Consultation identification number	PK
Nat_NatureId	Nature of consultation identification	FK to NATURE
Con_DateTime	Consultation date and time	
Con_FirstFollow	First / Follow-up consultation	
Con_MainComplaint	Patient's main complaint	
Con_Length	Patient stature in metres	
Con_Weight	Patient weight in kilograms	
Con_AbdomCirc	Patient abdominal circumference (cm)	
Con_Temp	Patient temperature	
Con_Pulse	Patient pulse rate	
Con_Breath	Patient respiratory rate	
Con_BloodPressure	Patient blood pressure	
Con_DiffDiagnosis	Differential diagnosis for consultation	

Table 5.2 Entity CONSULT

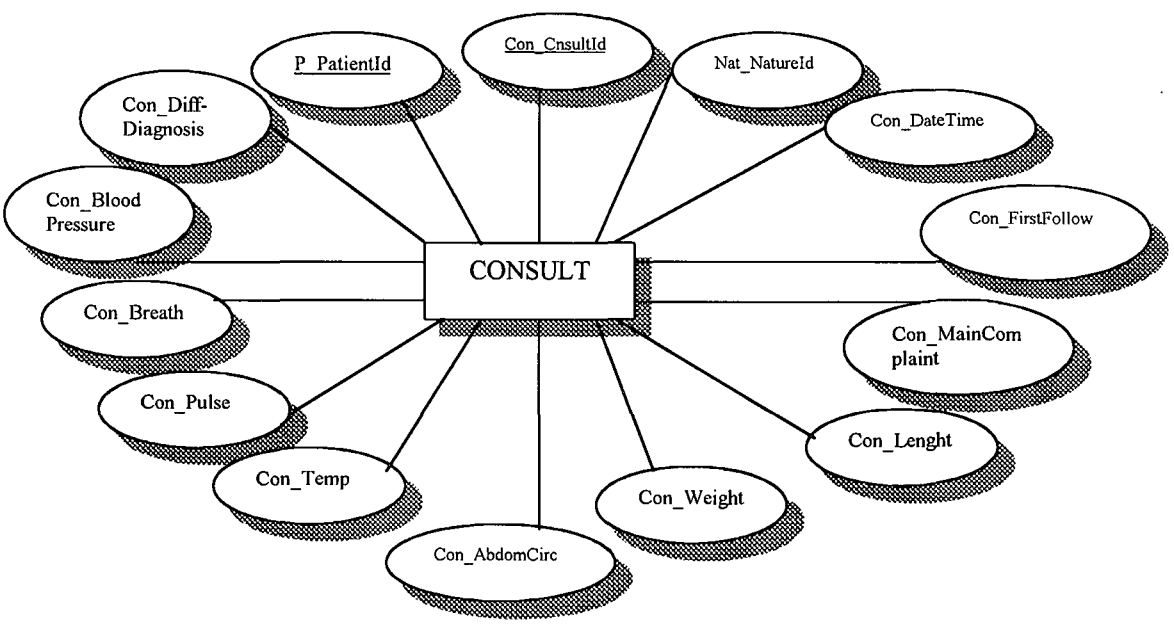


Fig. 5.3 E-R diagram of the attributes of entity CONSULT

P_PatientId	Con_ConsultId	Nat_NatureId	Con_DateTime	Con_FirstFollow
P1	1	1	1999-04-07 10:00 AM	First
P3	5	1	1999-04-09 11:30 AM	Follow

Con_MainComplaint	Con_Length	Con_Weight	Con_AbdomCirc	Con_Temp
Abdominal pain	1,82	90	80	36
Head-ache	1,72	75	100	38

Con_Pulse	Con_Breath	Con_BloodPressure	Con_DiffDiagnosis
80	80	140/80	Ulcer
110	90	150/80	Referred for scan

Table 5.3 Sample data of entity CONSULT

5.4 User interface issues

It has been stated [De Wet 1994] that a user interface is a major factor affecting the ability of users to learn and use computer systems. Although computer users may use documentation or formal instruction, their ultimate interaction is via the interface. Although a detailed discussion on user interface issues is beyond the scope of this thesis, some user interface issues need attention at this stage. These issues include:

- The type of user interface
- Components used
- The colour scheme
- User assistance.

These four issues will now be discussed in turn.

5.4.1 The type of user interface

A number of types of human-computer interfaces have been developed over the past few years as a result of technological advances in personal computer hardware and software. These interface types have been classified in many different ways. The most general classification divides user interfaces into character-based and graphical-based user

interfaces. The term "character-based user interface" includes interface types such as form-filling interfaces and command-language interfaces. The term "graphical-based user interface", in turn, includes direct manipulation and WIMP (**W**indows, **I**cons, **M**enus and **P**ointers) interfaces [Dix 1998].

The results of the questionnaire, as discussed in Chapter 4, indicated that a mouse and keyboard were both preferred as a means to manipulate data via the computer. It was therefore decided to design a mainly graphical user interface for the first prototype. The word "mainly" is used, as in some cases aspects of character-based and graphical-based interfaces are combined. In entering demographic information on a family or patient, a form-filling interface style is used, where information is either typed in, or selections made via the mouse. The form-filling interaction style facilitates the correlation between the manual and electronic versions of the records. Users move from field to field by pressing the Tab-key on the computer keyboard.

It was also decided not to include menus as part of the user interface. Menus did not seem viable in this specific instance. The reason for this decision was that the design of the user interface presented the user with all the available actions in the form of buttons on the screen. A menu would not serve a worthwhile additional purpose.

5.4.2 Components used

A variety of components are used to facilitate interaction with the system. Edit controls and memo fields are used to allow the user to type in certain information. This is particularly common in the form-filling parts of the system, for example where family and patient information are entered.

Drop-down combo boxes are used wherever the user is presented with a choice among two or more items. The user clicks on the appropriate choice using the mouse. Another instance where the mouse is used, is where the user is presented with a grid (table) of information. By double-clicking on the specific row on the grid, a choice is made.

Check boxes are used in cases where the user is allowed to select more than one of the presented options. By clicking on the check box, a " ✔ " is inserted into the box.

To assist users in moving between the information of different patients, the Navigator component is used. The manner in which this component is set up in the first prototype, allows the user to move to the next patient, the previous patient, or jump to the first or the last patient's information record. Buttons are also extensively used to present users with certain actions. These actions involve saving, deleting, or cancelling information, as well as clearing a screen from information or moving to a different screen.

5.4.3 The colour scheme

In user interface literature, the use of colour in user interfaces receives prominent attention. It is well known that the judicious use of colour can add meaning and functionality to a user interface. On the contrary, the use of colour in abundance without ensuring the purpose thereof, can give rise to the so-called "Las Vegas affect". This implies a very colourful screen that will attract the user's attention at first, but after a few minutes distract attention from the task at hand and even tire/hurt the eyes [Shneiderman 1998].

It was decided to use "Teal" as the main colour of the first prototype. The reason for this choice is that the colour is very "soft" on the eyes. In combination with "Aqua" for the grids, and "Silver" for the buttons, it presents a harmonious screen.

In some cases white labels are used to indicate the possibility of double-clicking on the label for more information. Where the user's attention needs to be attracted, red is used. An example is the red grid indicating a patient's allergies.

5.4.4 User assistance

Bearing in mind that this system is intended to be a prototype, no specialised help-files were written for it. User assistance is catered for with the aid of a status bar where the current status of the system, or results of user actions are displayed. Hints are displayed whenever the mouse cursor rests on a certain component (so-called bubble-help). Much attention was also given to descriptive labels and a meaningful screen layout in order to allow the screens to "speak for themselves".

With the basic user interface principles in place, the description of the first EPR prototype system can proceed.

5.5 Description of the first prototype

The first prototype was designed in close co-operation with the Department of Family Medicine at the University of the Orange Free State. Detailed discussions were held in order to establish how medical records are presently kept and how to transfer that information to an electronic version. Throughout these discussions, the requirements of the questionnaire participants were considered as well. As a result, it was decided to base the first prototype on the way current paper records are compiled. This implied that every consultation would be organised according to Weed's Subjective, Objective, Assessment, and Plan (SOAP) model [Weed 1969]. This decision facilitated the discussions with the physicians and gave them a point of reference.

The description of this prototype will be arranged according to the different screens presented to the user. The Logon screen will be first, followed by the Family screen, the Patient screen, the Previous consultation screens, the Problem list, the History screens, the Systemic history screen, the Examination screen, the General appearance screen, the Sideroom examination screen, the Systemic examination screen, and the Plan screen.

5.5.1 Logon screen

When signing on to the system, a user code and password are required (Fig. 5.4). The questionnaire respondents deemed security of the system as extremely important. Although this prototype does not yet cater for detail levels of access control, this issue will be addressed in later prototypes and in the final system.

When user code and password information are accepted, the user is brought to the screen where the family's information must be entered.

5.5.2 Family screen

The information on the Family screen has a direct bearing on the main member of the medical aid, and is required to enable the medical practitioner to send the medical accounts (Fig. 5.5).

One of the important problems that the questionnaire respondents experience with their current manual systems, is file-retrieval. In order for a computer system to be acceptable, a physician has to have a quick and convenient method of retrieving patient information. Record retrieval was provided for in this prototype in the following way: when entering the Family screen for the first time, an existing family can be located by either typing the Family account number, or the Family surname (or part thereof) in the corresponding two fields in the grey area on the screen. When typing the account number, the information for the specific family will be displayed on the screen. When the surname, or part of the surname is entered as a search criteria, a list of all the families that correspond to the search criteria will be displayed in a grid on the left-hand side of the screen. The user may then select the appropriate family by double-clicking on the entry on the grid. The selected family's information will be displayed. When a new family needs to be located, the Search-button may be pressed to allow for the search fields to appear on the screen again.

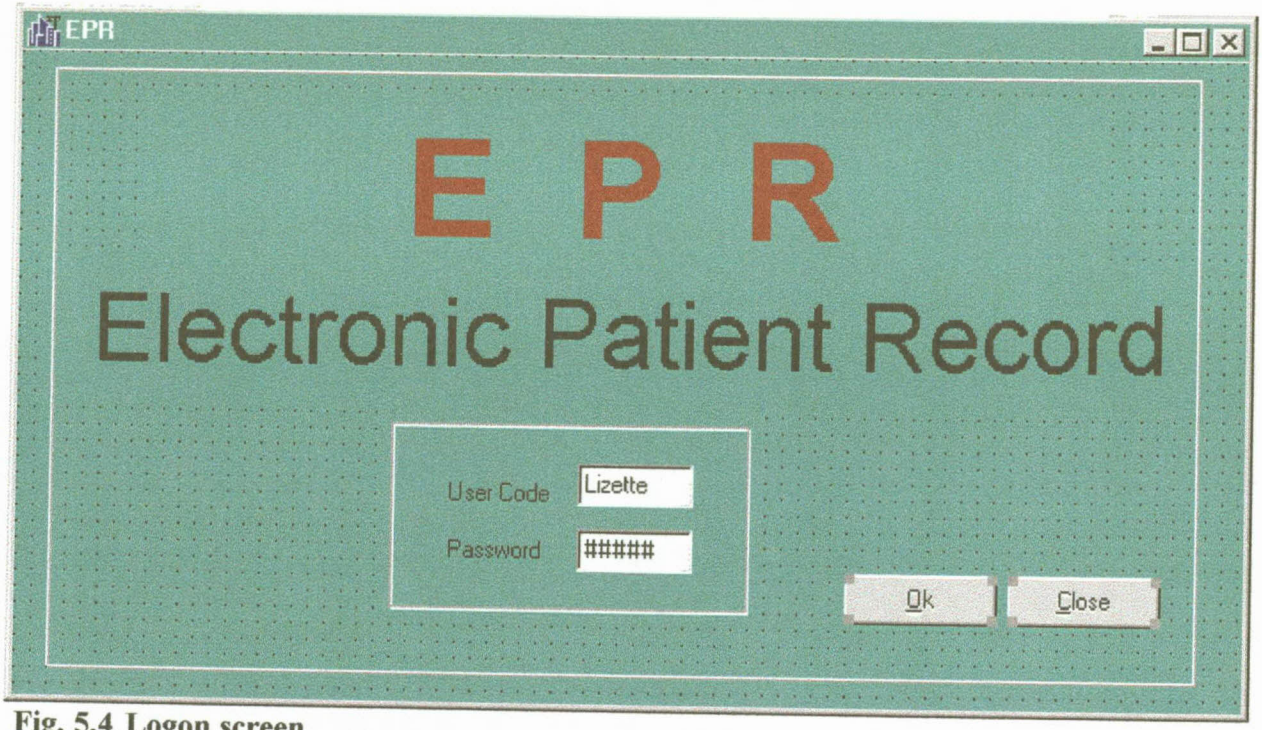


Fig. 5.4 Logon screen

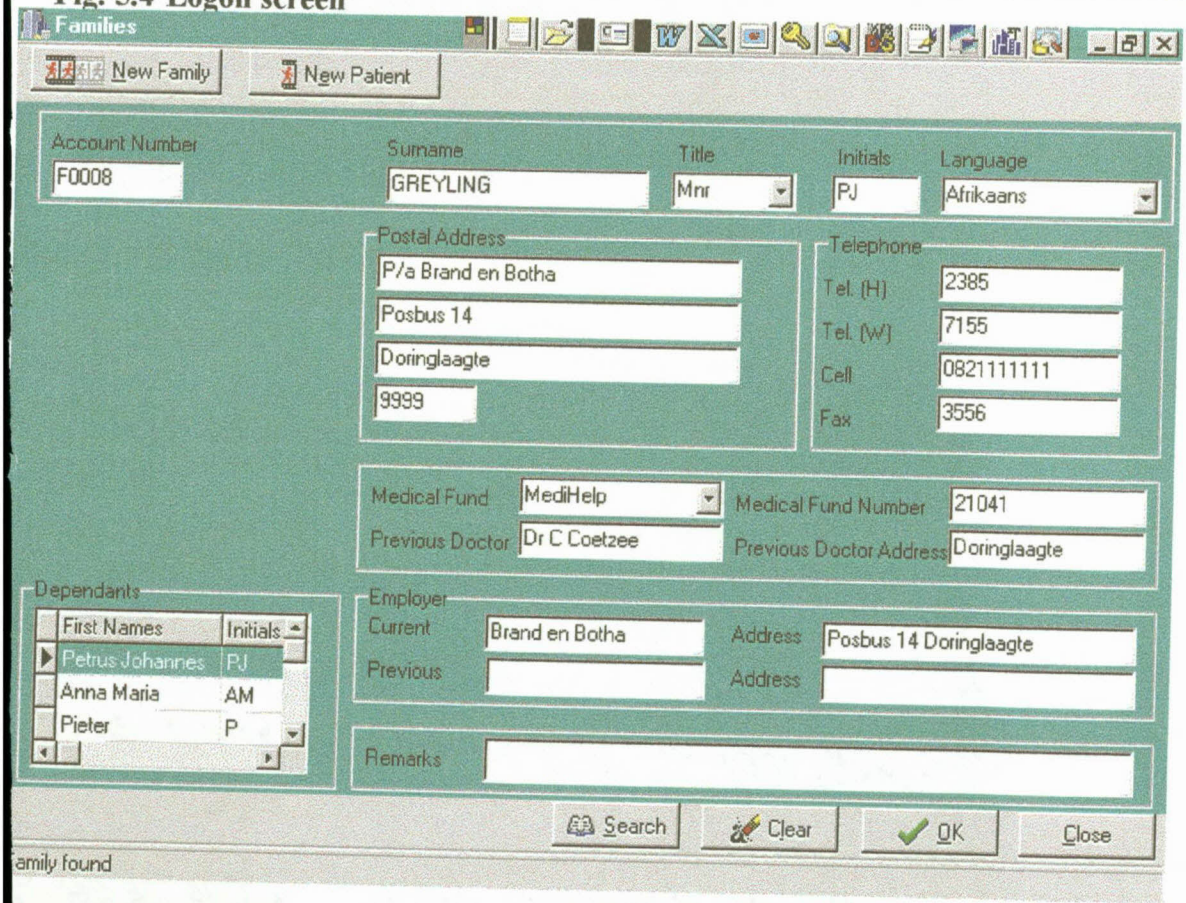


Fig. 5.5 Family screen

All the dependants of the main member of the medical aid are listed on the left-hand side of the screen. This gives the user an opportunity to select the specific patient for the current consultation (by double-clicking on the patient name in the Dependent-grid), or to create a new record for a new patient (by clicking on the *New Patient*-button). At this stage it is important to note that the receptionist can enter the personal information on the Family and Patient screens before the patient enters the physician's consulting room, as was requested by the questionnaire respondents.

When entering the information for a family the first time, the New Family-button is pressed and the user may proceed by typing in the appropriate fields or selecting an option from a drop-down combo box where applicable. After being satisfied with the information entered, the OK-button may be pressed to save the information.

The Clear-button at the bottom of the screen clears all the entry fields on the screen, while the Close-button is pressed to close the family screen and exit the application.

5.5.3 Patient screen

When presented with the patient information on the Patient screen (Fig. 5.6), a grid appears listing the dates and times of all the previous consultations of that specific patient. If the physician so requires, he/she can select one of the previous consultations and can then review the information pertaining to that consultation (see section 5.5.4).

The patient screen contains the personal information relating to the specific patient, for example first names and date of birth. Important allergy information about the patient appears in red in a grid at the top right-hand side of the screen. This is meant to attract the physician's attention as soon as the screen is loaded. The user may move between different patients belonging to the selected family in more than one way. The cumbersome way is to close the Patient screen (click on the Close-button at the bottom right-hand corner of the screen), and to then select the appropriate patient from the Dependants-grid by double-

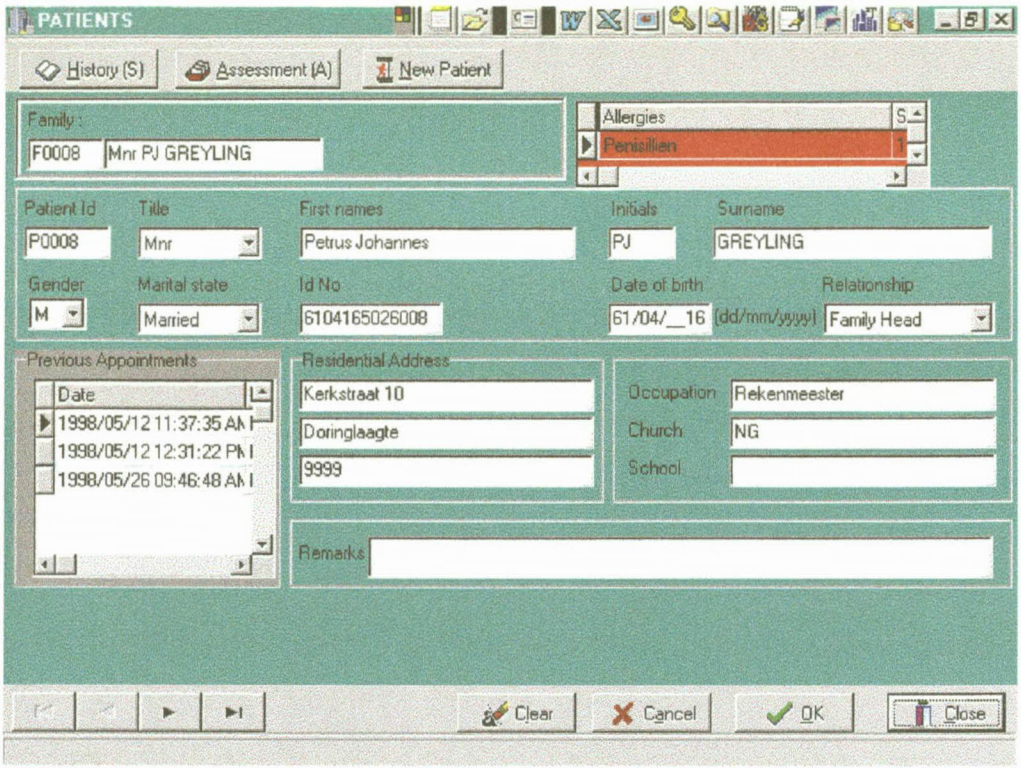


Fig. 5.6 Patients screen

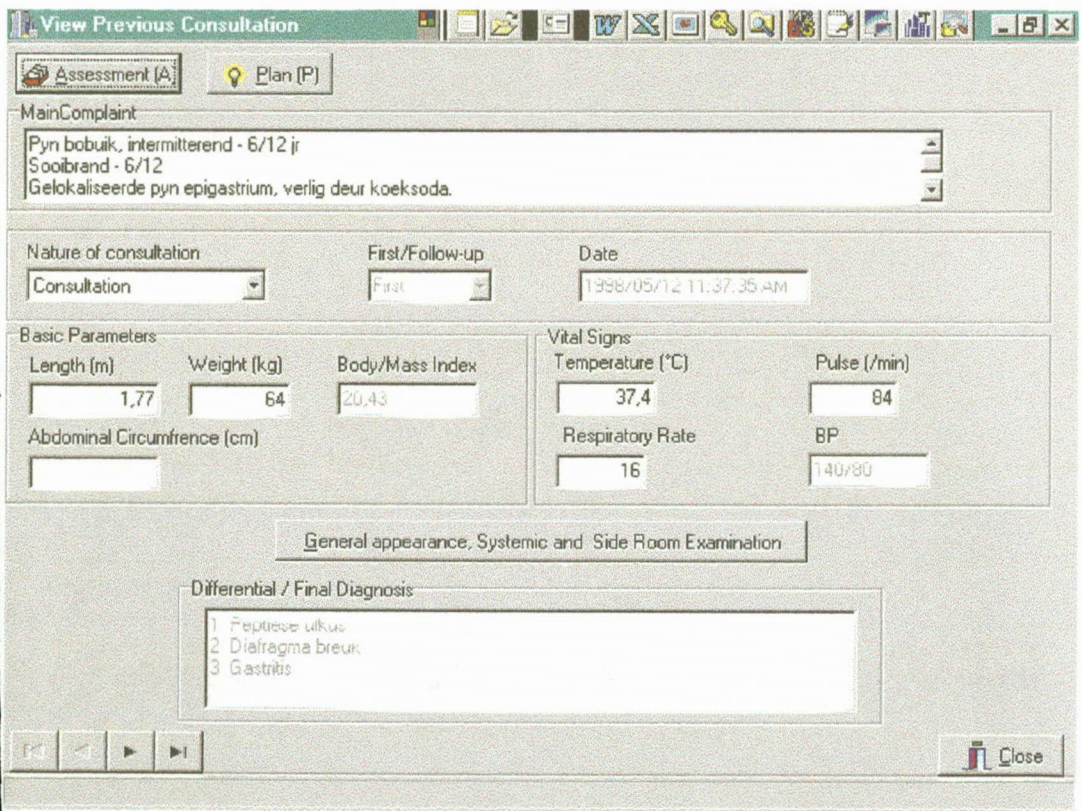


Fig. 5.7 Previous consultation screen

clicking on the name. An easier way is to use the Navigator component situated at the bottom left-hand side of the screen. By pressing the forward arrow, the user is navigated to the next patient(s) belonging to the family. The backward arrow does the opposite. The left-most button will display the first patient created for the family and the right-most arrow, the last patient for this family.

Three buttons appear near the top of the screen, namely the History, Assessment, and New Patient buttons. The History-button is pressed to start recording the consultation (see section 5.5.6), the Assessment-button to view the problem list of the patient (see section 5.5.5), and the New Patient-button to create a new patient belonging to the family displayed on the top left of the screen.

At the bottom of the screen another four buttons appear, namely Clear, Cancel, OK, and Close. The Clear-button is used to clear all the information from the input fields on the screen and the Cancel-button to cancel a new patient record while busy entering the information. The OK-button saves the patient information on the screen, while the Close-button closes the Patient screen and returns the user to the Family screen.

5.5.4 Previous consultation screen

As briefly mentioned above, this screen displays information pertaining to previous consultations of a specific patient (Fig. 5.7). Separate windows are displayed for the Plan-information (Fig. 5.8), as well as for the General appearance, Systemic, and Sideroom examinations (Fig. 5.9) of the specific previous consultation.

5.5.5 Problem list

The physician also has the option to view the problem list of the patient, listing the problem numbers, the problems (with dates), and outcomes (with dates) (Fig. 5.10). The user types in the problem and/or outcome of the problem, selects the appropriate consulta-

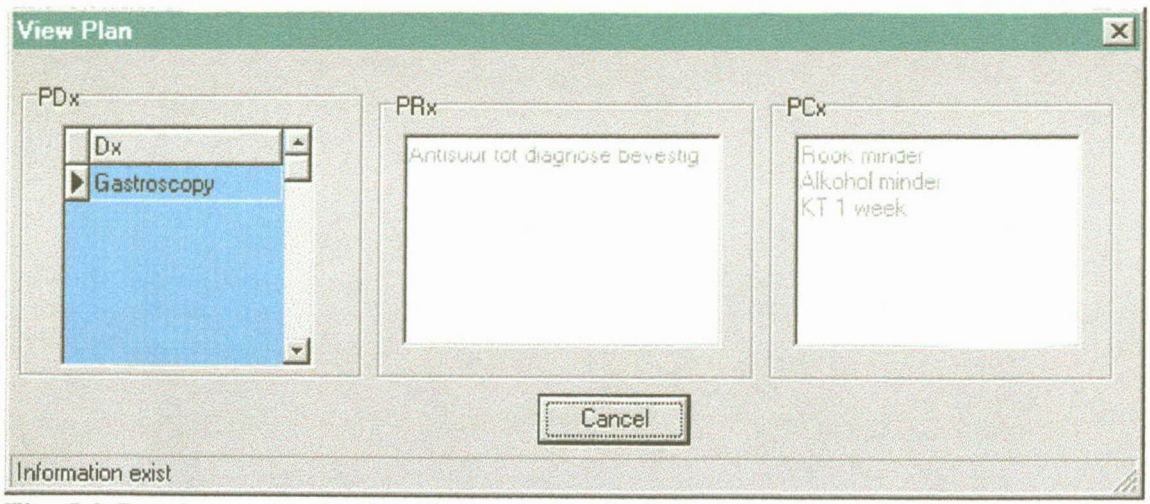


Fig. 5.8 Previous consultation Plan screen

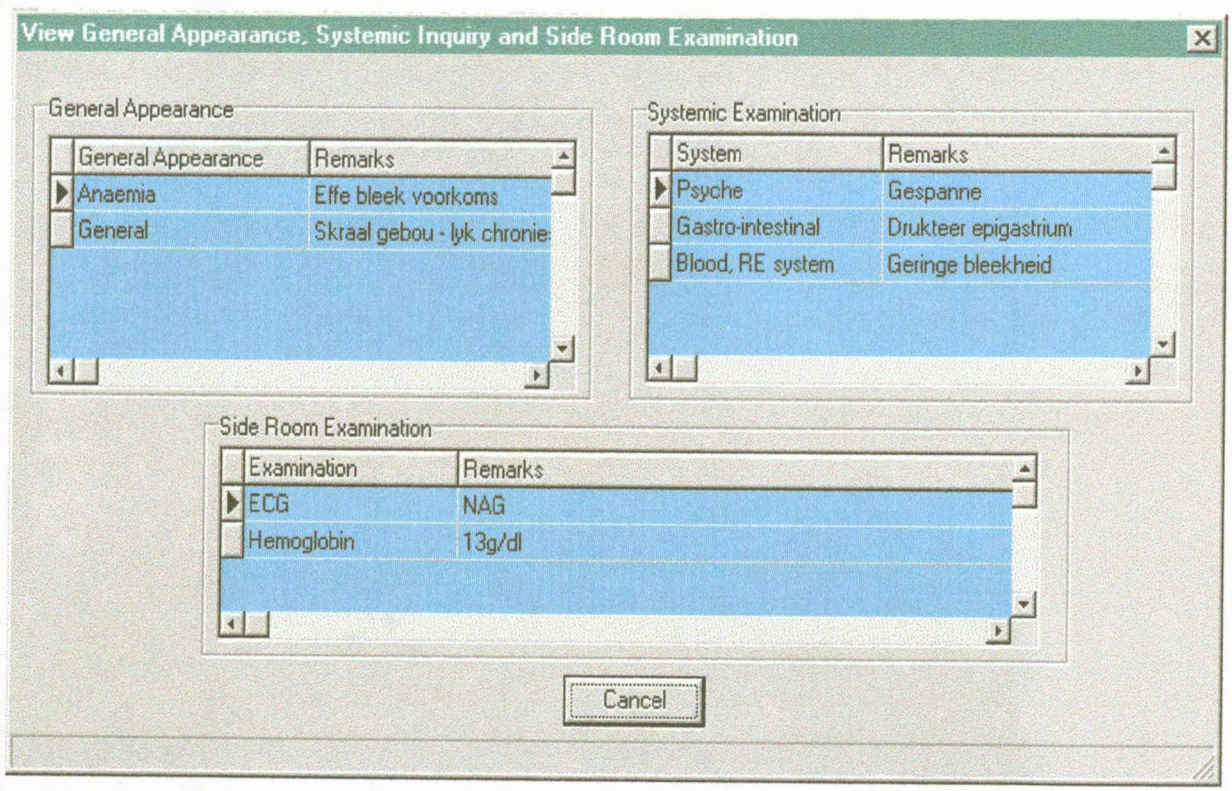


Fig. 5.9 Previous consultation General appearance, Systemic, and Sideroom examinations screen

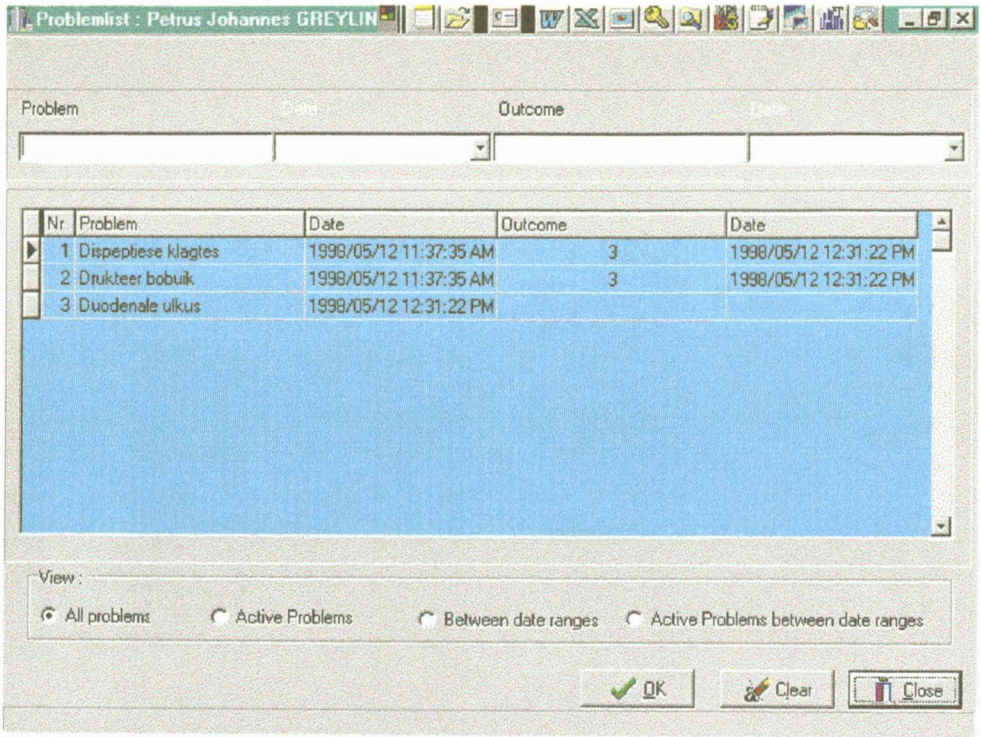


Fig. 5.10 Problem list screen

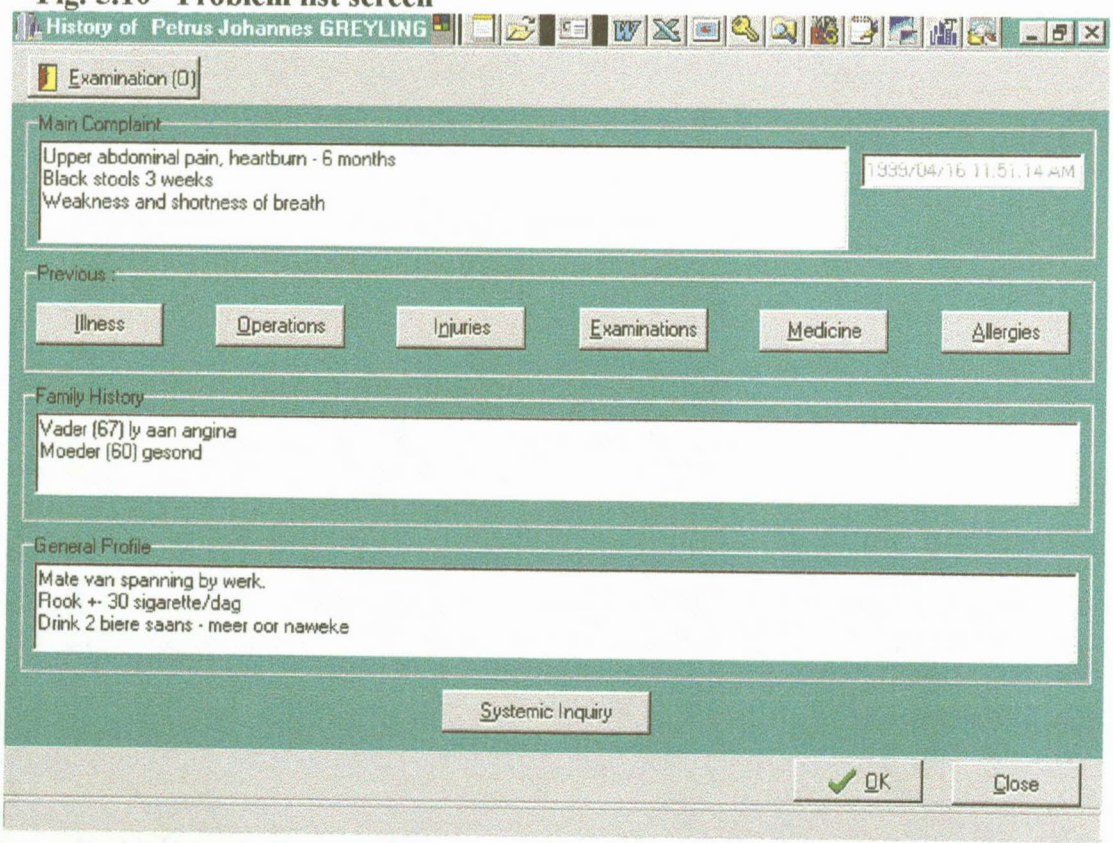


Fig. 5.11 History screen

tion dates and presses the OK button to save the information. The problem will be listed with the rest of the patient's problems in the grid on the screen.

At the bottom of the screen the user is presented with four viewing options. The first option will display all the patient's problems, the second option will display only the current problems, meaning those that do not have an outcome associated with it. When selecting the third option, a calendar will be displayed on which the user can select two dates. All the problems between the selected date range will then be displayed. Similarly, the fourth option will display the calendar and will then display all the active problems between the selected date range.

The Clear-button at the bottom of the screen will clear the input fields for the problem, problem date, outcome, and outcome date, while the Close-button will close the Assessment screen and return the user to the screen from where the Assessment screen was called from.

5.5.6 History screen

As previously mentioned, every consultation is organised according to the SOAP model. When a new consultation has to be recorded, the user can start by pressing the History button on the Patient screen (This represents the "Subjective" part of SOAP).

On the history screen (Fig. 5.11), the main complaint should be entered. The user can also view or add information regarding previous illnesses, previous operations, previous injuries, previous examinations, previous medication, and allergies. As these screens function in basically the same manner as the Previous Illness screen, only this screen will be presented in Fig. 5.12 as an example. The Previous Examinations screen will, however, also be presented (Fig. 5.13), as this screen additionally provides for the results of these examinations.

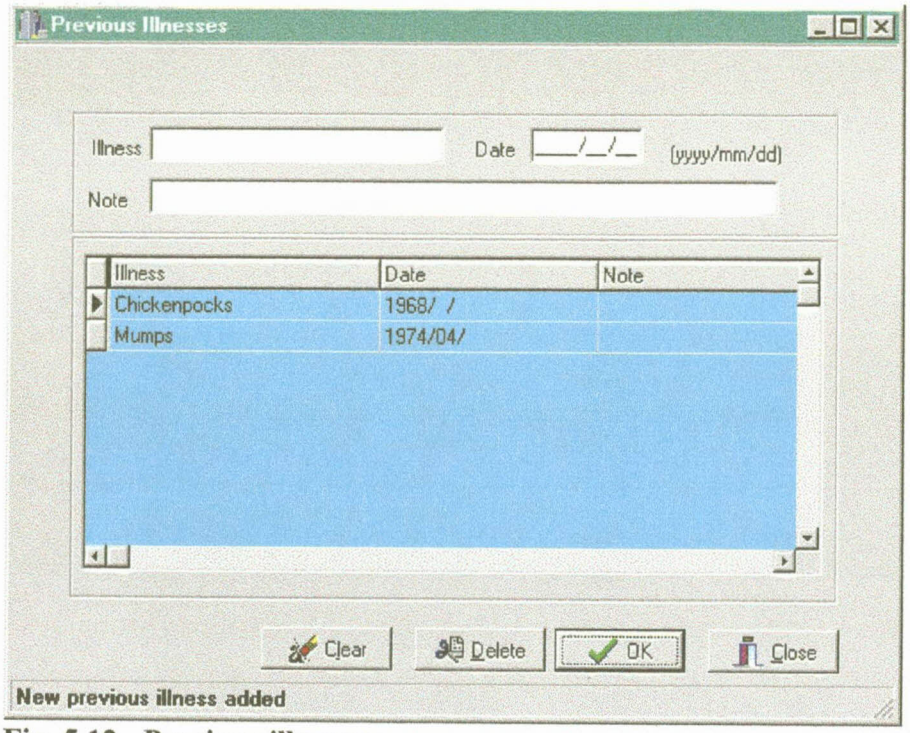


Fig. 5.12 Previous illnesses

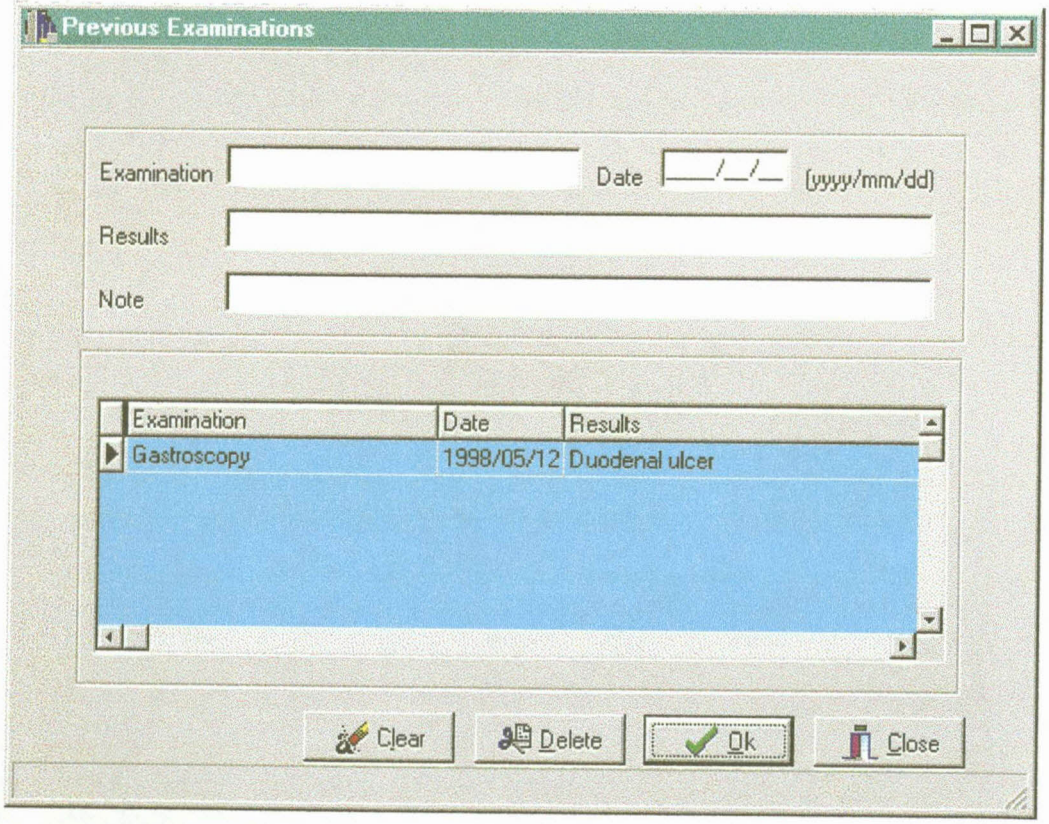


Fig. 5.13 Previous examinations

The Family History and General Profile are also addressed. The user can choose to view/enter information regarding the systemic history that makes provision for history of all body systems, from the Psyche to the Blood and RE System (see section 5.5.7).

When satisfied that all the entered information is correct, the OK-button may be pressed to save the history information. To proceed with entering the consultation, the Examination (O)-button at the top of the screen may be pressed. This brings the user to the Examination screen, which constitutes the "Objective" part of the SOAP model. The Examination screen will be explained in section 5.5.8.

5.5.7 Systemic history screen

On the Systemic history screen (Fig. 5.14), the thirteen systems (as were classified at that stage by the Department of Family Medicine, University of the Orange Free State) are listed on the left-hand side of the screen. These systems are: Psyche, Central nervous, Eyes, Ear, nose & throat, Cardio-vascular, Respiratory, Breasts, Gastro-intestinal, Uro-genital, Muculo-skeletal, Ectoderm, Endocrine, and the Blood & RE systems. The reader is reminded of the 82% of questionnaire respondents that indicated that they do indeed use this "from head to toes" framework/scheme during a consultation – therefore this choice of design is appropriate.

When information on a specific system is available, the user has to click on the check box next to the appropriate system. If any additional information regarding the history of the system exists, it can be typed into the memo field to the right of the check box. When satisfied that the entered information is correct, the OK-button may be pressed. This will return the user to the History screen. To cancel the entries, the Cancel-button may be pressed.

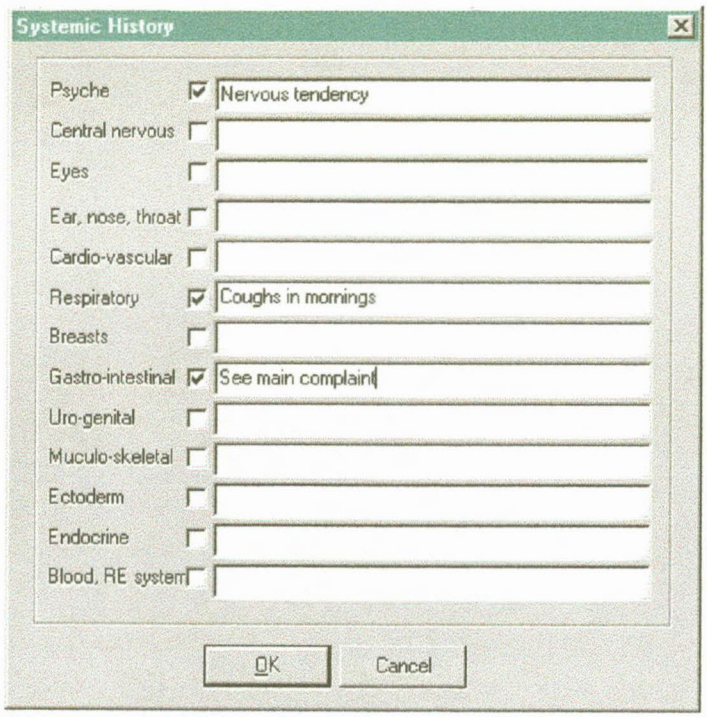


Fig. 5.14 Systemic history screen

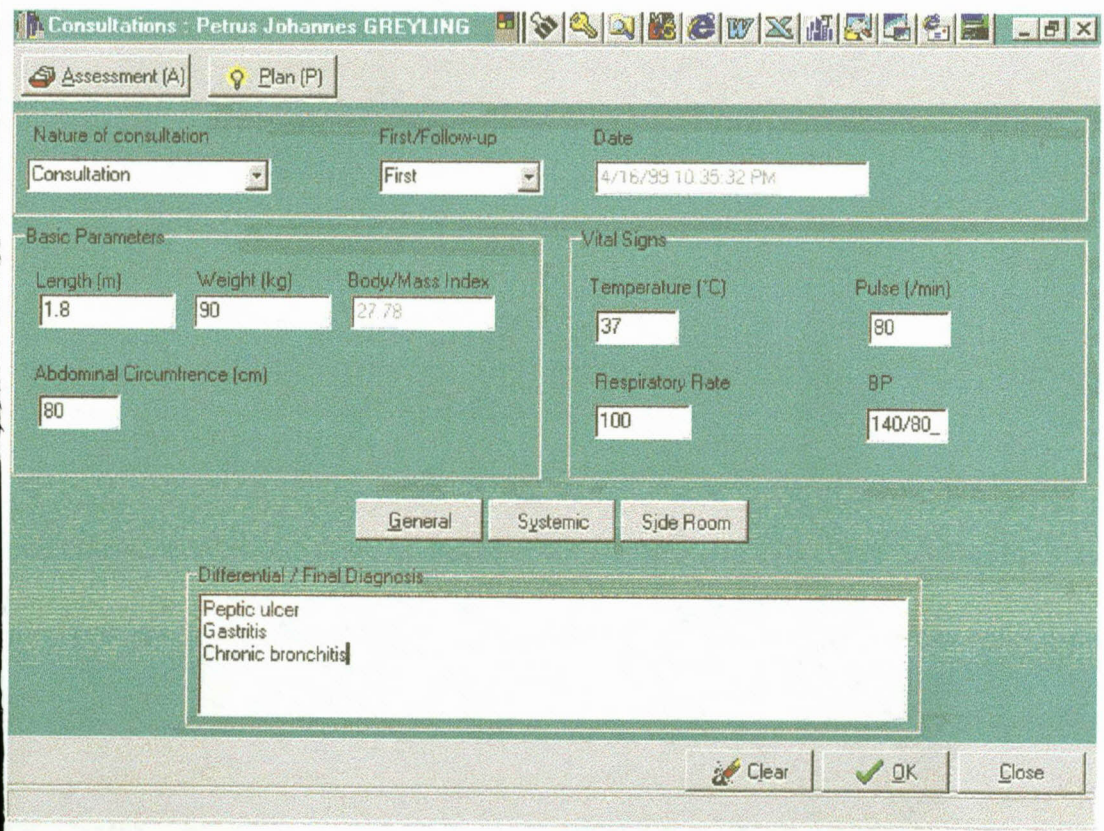


Fig. 5.15 Examination screen

5.5.8 Examination screen

The Examination screen in Fig. 5.15 contains fields regarding the nature of the consultation, whether it is a first or a follow-up consultation, the consultation date, the basic parameters (length, weight, body mass index, and abdominal circumference) and vital signs (temperature, pulse, respiratory rate, and blood pressure). The screen also provides access to information regarding the patient's General appearance (e.g. Jaundice, Anaemia and Cyanosis) via the General-button to the Systemic examination (regarding this specific consultation in contrast to the history pertaining to these systems on the Systemic history screen) via the Systemic-button and to the Sideroom examinations (e.g. hemoglobin or pregnancy test) via the Side Room-button. These three screens will be discussed in sections 5.5.9, 5.5.10 and 5.5.11 respectively.

The last section to be entered on the Examination screen before moving on to the Plan screen, is the Differential/Final diagnosis.

As mentioned before, new or existing problems on the problem list can be addressed by clicking on the Assessment-button at any stage during the consultation.

5.5.9 General appearance screen

The General appearance screen (Fig. 5.16) allows the user to click on a check box next to a specific general appearance condition when that condition is true for the patient. These conditions are Jaundice, Anaemia, Cyanosis, Glands, Clubbing of Fingers, and Oedema. Provision is also made for entering general information regarding the general appearance of the patient in the General category. Additional information may be entered in the memo field provided at the right-hand side of each check box. The OK-button may be clicked to save the information, while the Cancel-button may be clicked to cancel the entered information.

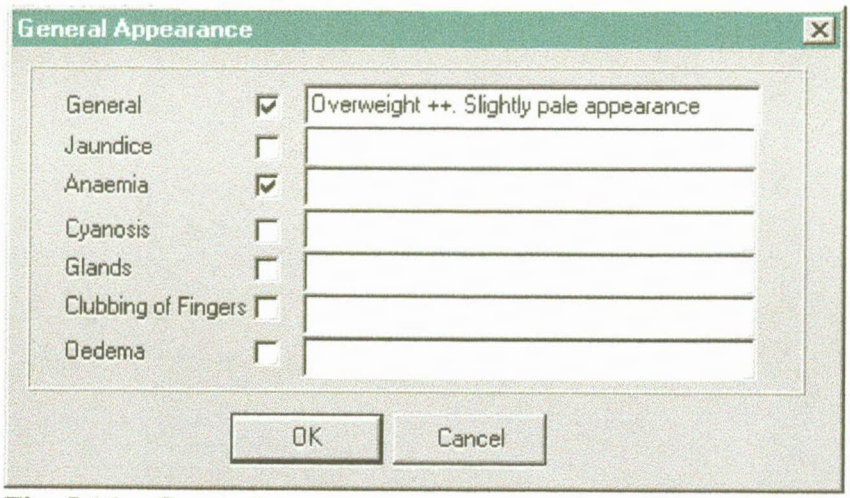


Fig. 5.16 General appearance screen

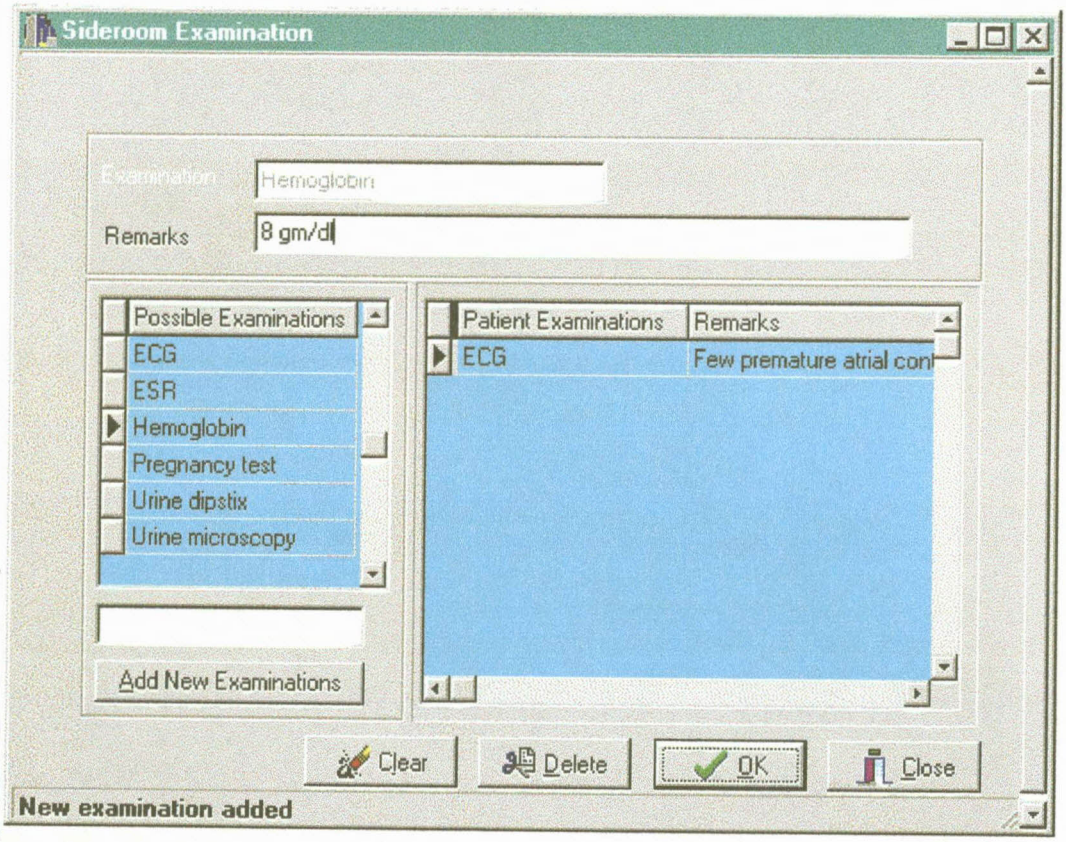


Fig. 5.17 Sideroom examination screen

5.5.10 Sideroom examination screen

Fig. 5.17 shows the Sideroom examination screen. The possible examinations that can take place are listed in the left-hand side grid. Each user compiles his/her own list of examinations. The user simply double-clicks on the appropriate examination. The examination will be copied to the Examination edit box at the top of the screen. The user may then proceed to enter remarks on the examination, where applicable. To save the examination information, the OK-button must be clicked. The information will then be transferred to the right-hand side grid, where all the patient's side-room examinations will be listed for this specific consultation.

Provision is also made to add any new examination to the list of provided choices. By typing the examination into the edit box below the Possible Examinations-grid, and clicking the Add New Examination-button, the new choice will be added to the existing list of choices. This option complies with the feedback from the questionnaires (Chapter 4) where the physicians indicated that customisation of choices would enhance an EPR system.

5.5.11 Systemic examination screen

The Systemic examination screen is identical to the Systemic history screen (see section 5.5.7) in it's functioning and is therefore not illustrated here. The information on the screen, however, relates to the current condition of the patient for the specific consultation, and not to the history of the patient.

5.5.12 Plan screen

On the Plan screen (Fig. 5.18), the physician can indicate the actions to be taken as a result of the consultation. This includes specific diagnostic measures, for example tests or examinations for which a patient can be referred, commonly known as Dx. Therapeutic

measures, such as the issuing of prescriptions, commonly known as Rx, and other patient counselling information, referred to as Cx, are also catered for. Although the first prototype does not make provision for the dispensing function, as was requested by the questionnaire respondents, the next prototype(s) and the final system might address this issue.

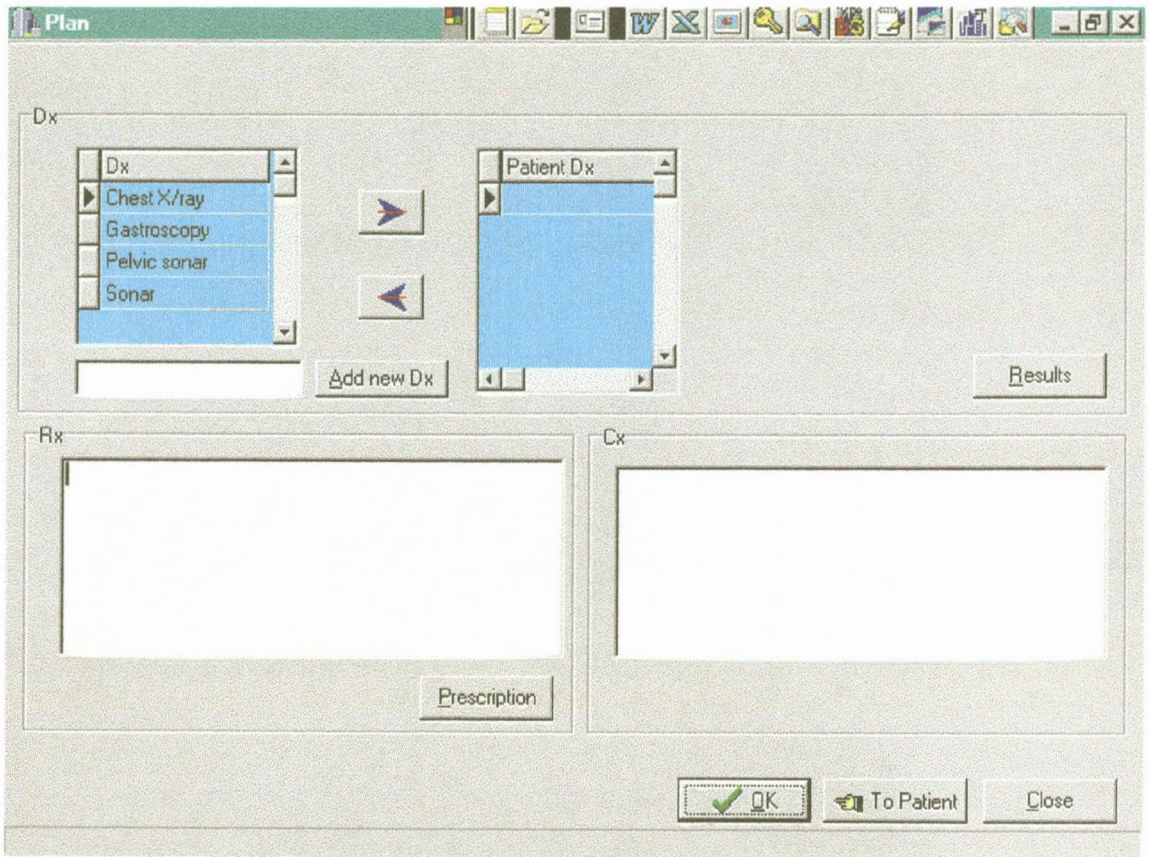


Fig. 5.18 Plan screen

At this stage of entering the consultation information, the user has the option to revise any information entered regarding the specific consultation. Once the user is satisfied that the consultation has been properly recorded, the consultation is concluded. After this, the physician would not be able to change the record. As is the case with the manual system, any post-consultation changes should be made by means of a "minutes method". This precaution is necessary for security and medico-legal reasons. Although the first prototype does not include a method for making these changes, the next prototype will provide the

user with a screen where a specific consultation per patient can be selected, and any additional information regarding that consultation can be entered.

The first prototype was now completed. It was time to find out whether the expectations and requirements of general practitioners regarding an EPR system were met ... it was time for the evaluation. The evaluation procedures and results will be discussed in Chapter 6.

5.6 Summary

In this chapter the design and development of the first EPR prototype system was explained and discussed.

The discussion kicked off with an explanation of the development environment. The database design then followed, including a brief introduction to database models, listing the entities, visually presenting all the relationships with the aid of E-R diagrams, and listing and explaining the attributes. Some important user interface issues were highlighted, followed by a description of the prototype by discussing each screen of the program respectively.

The procedures that were followed to evaluate the first prototype EPR system, as well as the results thereof will be discussed in the following chapter.

Chapter 6

Evaluation of the First Prototype

6.1 Introduction

In Chapter 5 the first EPR prototype system was discussed extensively. It is essential, however, to test the prototype as well as to assess the user interface design to ensure that it actually behaves as was expected and meets the requirements of the user. This is the role of evaluation. This chapter will commence with a brief background highlighting the principles of evaluation. This discussion will be followed by an explanation of the evaluation processes employed in evaluating the first prototype. The evaluation results will also be discussed.

It must be stressed that the field of evaluation is vast and that a full explanation/discussion of the related issues falls outside the scope of this thesis. The reader is referred to the references indicated for more information on these topics (work done by Friedman and Wyatt [1997] is worth mentioning here). An attempt will, however, be made to provide brief explanations where considered necessary.

The vast field covered by the term *evaluation* (as mentioned above) has resulted in many different evaluation approaches and methods. It is therefore necessary to admit that other existing approaches might have been followed with the same (or even better) results. One such evaluation method is scenario-based evaluation. In the development of requirements for interactive systems, this method takes the role of context into account [Harrison 1997]. Scenarios provide an insight into what kinds of operational demands are imposed on the real-life use of a proposed design and how this gives rise to additional cognitive demands for practitioners caught up in. Dekker [1997] adds that by becoming directly involved in the design process through the construction and definition of scenarios,

practitioners may be encouraged to plough their skills, domain expertise, tacit knowledge, etc. into the process.

The existence of other evaluation methods necessitated certain choices and tradeoffs regarding the evaluation methods applied for the purpose of this thesis. A decision was made to focus on usability evaluation. The main purpose of the thesis is to present an EPR model (refer to Chapter 10), and not a final application. This, as well as the fact that the majority of the physicians who participated in this research project were confronted with an EPR system for the first time (the prototypes were regarded as a starting point to get their "ideas and creativity going"), made the usability aspect seem more appropriate. When evaluating the design process of an EPR system based on the EPR model proposed in this thesis, however, scenario-based evaluation (for example) might be applied with great success.

6.2 The principles of evaluation

Preece [1994:602] states that "evaluation is concerned with gathering data about the usability[1] of a design or product by a specified group of users for a particular activity within a specified environment or work context".

In order to explain the role of evaluation for the purpose of this thesis, the following aspects will be covered:

- Evaluation goals
- Evaluation styles
- Evaluation methods.

[1] Usability can be viewed as the quality of interaction between the user and the other parts of the work system [Dix 1998].

6.2.1 Evaluation goals

Evaluation (as seen in the context of this thesis) has three main goals, namely [Dix 1998]:

- To assess the extent of the system's functionality
- To identify any specific problems with the system
- To assess the effect of the interface on the user.

6.2.2 Evaluation styles

Two main styles of evaluation may be distinguished, namely laboratory studies and field studies [Dix 1998]:

- **Laboratory studies** – This style of evaluation studies the use of a system within a laboratory. It may involve the designer[2] performing some assessment of the design without the involvement of users, or users may be brought into the laboratories to be involved in the assessment.

  These studies normally require a well-equipped laboratory called a usability laboratory. Such a laboratory would ideally consist of two rooms, divided by two-way mirrors. The designer would occupy the first room, while the user assisting in the assessment would occupy the second room. Sophisticated audio/visual recording facilities, as well as instrumented computers are the last required finishing touches for such a laboratory. It is needless to mention that great costs are involved for such a setting [Shneiderman 1998].

  There are cases where laboratory observation is the only option. An example is where alternative designs need to be compared within a controlled environment.

[2] For the remainder of the thesis, the terms *designer* and *evaluator* refers to the same person, namely the author.

- **Field studies** – In contrast to laboratory studies, field studies would take a designer out into the user's working environment to observe the system in action. Where laboratory tests are performed in a controlled interruption-free environment, the opposite is true of field-testing. The evaluation takes place in the user's *natural environment*, with all the related noise, movement, and constant interruptions [Preece 1994]. A variation on the "traditional" field test supplies users with test versions of new software [Shneiderman 1998].

It is difficult to say which of the above-mentioned two styles are the best. It all depends on circumstances. In some cases a combination of the two styles would be preferable.

6.2.3 Evaluation methods

Evaluation should take place throughout the process of designing a computer system, as well as after it has been implemented [Preece 1994]. It is therefore plausible to make a broad distinction between evaluation of the design of an interactive system and evaluation of an implementation, whether full or prototype [Dix 1998]. Each of these two alternatives will now be discussed in turn.

6.2.3.1 Evaluating the design

Evaluating the design typically involves analysis by the designer rather than testing with actual users. Four possible approaches to evaluate a design will be considered, namely cognitive walkthrough, heuristic evaluation, review-based evaluation, and model-based evaluation [Dix 1998].

- **Cognitive walkthrough** – The goal of a cognitive walkthrough is to detect problems very early on so that they may be removed [Preece 1994]. In the cognitive walkthrough the evaluator steps through an action sequence (the steps that an interface will require a user to perform in order to accomplish some task) to check it for potential usability problems. The evaluator basically "puts himself in the shoes of the user". The main focus of the cognitive walkthrough is said to be

learning through exploration – many users prefer to learn how to use a system by exploring its functionality hands-on. During the walkthrough questions are asked that address this exploratory learning [Wharton 1994].

- **Heuristic evaluation** – Molich and Nielsen [1990] devised a method known as *heuristic evaluation* in response to the need for cheaper, cost effective methods that could be used by small companies who could not afford, nor had the facilities, time or expertise for the alternative evaluation methods. A heuristic is defined as "a guideline or general principle or rule of thumb that can guide a design decision that has already been made" [Dix 1998:412]. Heuristic evaluation, therefore, is "a method for structuring the critique of a system using a set of relatively simple and general heuristics" [Dix 1998:412]. Several evaluators independently critique a system to come up with potential usability problems. Although it is best used for evaluating early designs, all that is needed for this type of evaluation is some sort of artifact that describes the system. The artifact can range from a set of storyboards giving an overview of the system, to a fully functioning system that is in use in the field [Molich 1990].

- **Review-based evaluation** – In review-based evaluation the evaluator uses existing literature for evidence to support (or refute) aspects of a design. This literature stems from a wealth of experimental results and empirical evidence gained though experimental psychology and human-computer interaction. In order for review-based evaluation to be successful, the evaluation should take account of both the similarities and differences between the experimental context and the design under consideration [Dix 1998].

- **Model-based evaluation** – Certain cognitive and design models provide a means of combining design specification and evaluation into the same framework. Informed judgements can be made in the design by examining the criteria that are associated with each option in the design, and the evidence that is provided to support these criteria [Dix 1998].

6.2.3.2 Evaluating the implementation

A replacement for actual usability testing with the people for whom the system is intended, namely the users, does not exist. The major difference between this type of evaluation and evaluation of the design is that an actual implementation of the system in some form exists. This implementation may range from a simulation of the system's interactive capabilities (without its underlying functionality), through a basic functional prototype to a fully implemented system. Four possible approaches to evaluate an implementation will be considered, namely empirical or experimental methods, observational techniques, and query techniques [Dix 1998].

- **Empirical or experimental methods** – Empirical or experimental methods involve a controlled experiment that provides empirical evidence to support a particular claim or hypothesis. The evaluator chooses a hypothesis to test, which can be determined by measuring some attribute of subjective behavior [Dix 1998].

- **Observational techniques** – An effective way to gain information about the actual use of a system is to observe users interacting with it [Preece 1994]. Usually they are asked to complete a predefined set of tasks. The record of an evaluation session of this kind is called a *protocol*. Three observation techniques that will be addressed, are protocol analysis, automatic protocol analysis tools, and post-task walkthroughs [Monk 1993].

  - **Protocol analysis**

    The methods for recording user actions in protocol analysis include:

    - Paper and pencil
    - Audio recording
    - Video recording
    - Computer logging
    - User notebooks.

- **Automatic protocol analysis tools**

  Protocol analysis is tedious and time consuming by hand. Automatic analysis tools to support the task offer a means of editing and annotating video, audio and system logs, and to synchronise these for detailed analysis [Monk 1993].

- **Post-task walkthroughs**

  A walkthrough attempts to alleviate lack of interpretation regarding data obtained via direct observation. The transcript of the evaluation (written or recorded) is replayed to the subject who is invited to comment, or is directly questioned by the analyst [Monk 1993].

- **Query techniques** – Query techniques are relatively simple and inexpensive techniques to get the user's viewpoint directly in order to reveal issues which have not been considered by the designer. These techniques, therefore, highlight users' attitudes towards the system [Preece 1994]. Personal interviews with users and the sending out of questionnaires are two well-known query techniques. Interviews have the advantage that the level of questioning can be varied to suit the situation. The evaluator can also probe more deeply into interesting issues as they arise. Questionnaires are less flexible but can be used to reach a wider subject group. It also takes less time to administer and can be analysed more rigorously. It can also be administered at various points in the design process [Dix 1998].

Now that a broad overview of evaluation principles has been given, and the evaluation methods available have been highlighted, the procedures followed to evaluate the first EPR prototype system will be discussed.

6.3 Evaluation procedures

In section 6.2.1 the goals of this evaluation were listed. In order to comply with the first and second goals, namely to assess the extent of the system's functionality and to identify

any specific problems with the system, it was decided to use query techniques (section 6.3.1). To assess the effect of the interface on the user (evaluation goal number 3), a heuristic evaluation was first conducted by the designer (section 6.3.2). Usability testing in the form of a combination of observational techniques and empirical methods to gain qualitative as well as quantitative information regarding the interaction of actual users with the first prototype (section 6.3.3) followed. A task analysis[3] also formed part of the latter.

The discussion of the evaluation procedures under the headings of *Query techniques, Heuristic evaluation,* and *Usability testing*, illustrates the author's own interpretation of evaluation method categorisation used in this thesis. The reason for mentioning this is that almost every textbook covering the topic of user interface evaluation categorises these methods differently.

At this stage it is important to note that the following discussion of the evaluation procedures involves the evaluation of the first prototype as a "complete system", but still forming part of a bigger design process consisting of more prototypes. Continuous evaluation *did* take place during the design phases of the first prototype. This evaluation generally took the form of a cognitive walkthrough. During such an evaluation session, a physician (an expert in the medical field and familiar with broad computer science principles) would "walk through" a certain part of the system along with the designer. Possible system functionality as well as user interface problems were highlighted. These cognitive walkthroughs were deemed to be of indispensable value to the design process.

Returning to the evaluation procedures of the "complete" (implemented) first prototype, the decision on which evaluation style to use, namely laboratory or field studies (refer to section 6.2.2), posed a minor problem. Usability laboratories are expensive to set up – as has been mentioned – and this option, therefore, was not at the disposal of the designer.

[3] Performing a task analysis is to try and make sense of what people should do or what they actually do [Diaper 1989:15].

Considering the "field" in which the prospective user community worked, namely busy general practitioner practices, made it impractical to launch field studies of a prototype system. Trying to convince busy general practitioners to use a prototype – a *first* prototype as such – EPR system as part of their day-to-day tasks, seemed to be a futile exercise.

It was then decided to present the first prototype to general practitioners at a conference by means of a presentation and demonstration and to use questionnaires / evaluation forms (part of query techniques as mentioned in section 6.2.3.2) as a means to perform the evaluation. A discussion on the query technique used will now be presented.

6.3.1 Query technique

The first prototype was demonstrated to a group of about one hundred physicians during a course for general practitioners held by the Department of Family Medicine at the University of the Orange Free State on the 16th of May 1998.

A presentation was given where the background of the EPR prototype was explained. The presentation was followed by an on-line demonstration of the system where real-life data was used. The session was concluded with an opportunity for questions from the audience. These questions and the feedback from the practitioners were deemed to be extremely meaningful and heartening.

Each participant was handed an evaluation form at the beginning of the session. They were asked to complete this evaluation form after the conclusion of the demonstration. This evaluation form can be viewed in Appendix E. On a scale from 1 (non-existent) to 5 (excellent), the practitioners had to rate certain aspects relating to the prototype. Ample space was provided for additional comments, critique, and recommendations.

In the next section, the results of the processed evaluation forms will be discussed.

6.3.1.1 Query technique evaluation results

The processed results of the evaluation forms gave valuable insight regarding the expectations practitioners have of an EPR system. Being confronted with an actual EPR system for the first time, most of the physicians now had the opportunity to visualise the use and impact of such a system. Being confronted with an EPR system in *practice* in comparison to a *theoretical* ideal, made it possible for physicians to come forward with practical advice, problems, and recommendations.

Table 6.1 provides the results to the questions on the evaluation form. These results are presented graphically in Appendix F. On a positive note (taking the "good" and "excellent" responses into account), the physicians were very positive regarding the ease of registering a family (83%), searching for a family (90%), registering a new patient (88%), and searching for a patient (92%). As these tasks are traditionally deemed to be cumbersome using a manual system, the response indicated that this is one of the best assets of the EPR system.

Sixty nine percent of the physicians felt that the system provides for all the basic clinical services rendered by a general practitioner, while 28% deemed this aspect as "fair". The positive response of 87% to "The system ensures that the entered data is valid to the greatest possible extent" might not be too meaningful, as this aspect could not be illustrated fully in a demonstration of this kind. As far as the provision for the total medical record as well as for sufficient information to run a practice, are concerned, 70% and 79% respectively indicated that the system complied with these requirements.

The system appeared to be easy to use (59%) and easy to learn (69%) and 61% were satisfied with the response time of the system. An enlightening fact was that 68% of the physicians indicated that they would *personally* use the system, while 25% were not entirely sure about this aspect. Another positive indication was the "fair"-reaction (36%), "good"-reaction (42%), and "excellent"-reaction (10%) that the statement "The system is precisely what I envisioned an electronic patient record system to be", received. This (at least) showed that we were on the right track with the EPR system.

EVALUATION QUESTION	NON-EXISTENT(%)	POOR (%)	FAIR (%)	GOOD (%)	EXCEL-LENT (%)
The task of registering a family is easy		3	14	51	32
There are convenient means to search for a family		2	8	49	41
The task of registering a new patient is easy.		2	10	47	41
There are convenient means to search for a patient.			8	44	48
The system provides for all the basic clinical services rendered by a general practitioner.		3	28	43	26
The system corresponds closely to the old way of doing things.	9	14	26	37	14
The system ensures that the entered data is valid to the greatest possible extent.		4	9	62	25
The system provides me with sufficient information regarding the clinical records in my practice.		2	19	45	34
The system provides for the total medical record.		3	27	32	38
It is easy to find what I need to do in the system.		3	33	38	26
The amount of typing I need to do is acceptable.	5	28	36	22	9
The interaction with the system is clear and understandable.		5	34	36	25
My productivity will increase by using the system.		26	38	18	18
Overall the system is easy to use.	2	8	31	42	17
Overall the system is easy to learn.			31	52	17
Overall the response time of the system is good.	2	9	26	44	19
I shall have more time for patient care during consultations.	3	41	38	16	2
I shall be willing to personally use this system.	2	5	25	32	36
I shall be willing to personally use this system in the presence of the patient.	11	12	30	26	21
The use of the system will maintain the relationship of trust with the patient.		17	38	31	14
This system is precisely what I envisioned an electronic patient record system to be.	3	9	36	42	10
I am willing to participate in the establishment of a generally acceptable electronic patient record system in the future.	5	2	12	31	50

Table 6.1 Results of the evaluation of the first EPR prototype system

There were, however, concerns regarding certain aspects of the system. In some cases these concerns were illustrated with a relatively high "fair" response to a question. Examples are the 33% "fair" response to "It is easy to find what I need to do in the system", the 34% "fair" response to "The interaction with the system is clear and understandable" (61% felt that this was the case), and the 38% "fair" response to "The use of the system will maintain the relationship of trust with the patient". The 26% "fair" response to "The system corresponds closely to the old way of doing things" is not necessarily bad, as a computer system does not need to closely resemble a manual system.

On the negative side, the physicians were doubtful as to whether the system would increase productivity (26% thought that it would not, while 38% were in doubt). Only 36% believed that productivity could increase. While the majority indicated that they would *personally* use the computer system, the response to using the system *in the presence of the patient* was not so positive. Eleven percent stated that they would definitely not use the system with the patient around, 12% did not feel comfortable with the idea, and 30% had doubts about this issue. Only 47% indicated that they would have no problem using the computer in the presence of the patient.

Taking the written comments, recommendations, and critique into account, the most significant problems that were highlighted, were the following:

- The system requires too much typing.
- The user is confronted with too many screens in the performance of his task.

The fact that physicians require less typing, can be seen from the negative responses to the questions "The amount of typing I need to do is acceptable" (32%), "My productivity will increase by using the system" (26%), and "I shall have more time for patient care during consultations" (44%). These responses, together with the response to the question

"It is easy to find what I need to do in the system", also indicate that there are too many screens.

Other concerns mentioned were the cost-factor, the possible jeopardisation of the relationship of trust between doctor and patient, confidentiality, the possibility of linking with existing financial systems, the use of a scanner to scan in specialist reports or images and the future use of speech as an input method.

Much reassurance can be given about these aspects when physicians are reminded of the status quo regarding current manual systems. Taking the issue of the relationship of trust as an example, the current manual systems would imply that the physician would put his/her pen down, look the patient straight in the eye and hear the patient out while trying to determine the main complaint. Only after that would he/she start writing the clinical notes in the presence of the patient. The situation need not differ substantially when using an EPR system for record taking. The same guidelines regarding the listening and eye contact apply, and after determining the main complaint, the physician would simply enter the information on the computer instead of writing a note. The precondition is that the computer should not be physically placed on the desk between the physician and the patient. It should be placed on a side table which the physician should be able to reach comfortably by simply rotating his / her chair.

The fact that 81% of the physicians indicated that they would be willing to participate in the establishment of a generally acceptable EPR system in future gave a clear impression of the need and enthusiasm for, and belief in the possible success of such a system.
In the following section the heuristic evaluation will firstly be discussed, to be followed by the usability testing that was performed in the form of observational techniques and empirical methods.

6.3.2 Heuristic evaluation

Heuristic evaluation is usually carried out during the design phase of system development. In the scenario of this thesis, however, it could successfully be carried out

on the different prototype systems as well. In comparison to evaluation methods during implementation where the prospective user is actively involved, this type of evaluation is usually performed by the designer.

Molich and Nielsen [1990] identify a list of ten heuristics to be used to uncover usability problems while critiquing the system:

- **Visibility of system status** – The system should always give the user appropriate feedback within reasonable time to keep him/her informed.

- **Match between system and the real world** – The metaphor (refer to chapter 1) chosen should facilitate presenting the user with familiar words, phrases, and concepts. Real-world conventions should be followed for information to appear in a natural and logical order.

- **User control and freedom** – Undo and redo actions should be supported. Users often choose system functions by mistake. Therefore clearly marked *emergency exits* should be provided without having to go through extended dialogue.

- **Consistency and standards** – Pre-defined consistency policies and standards would facilitate ensuring an interface that is consistent throughout. Consistency can pertain to screen-layout, colour choices, error message wording, etc. The user should not have to wonder whether different words, situations or actions mean the same thing.

- **Error prevention** – A careful design that would prevent errors from occurring in the first place is even better than good error messages.

- **Recognition rather than recall** – The user should not have to remember information from one part of the system to the next. Objects, actions, and options available should be visible, as well as instructions for using the system.

- **Flexibility and efficiency of use** – A system should cater for inexperienced as well as experienced users. This can be done by providing accelerators to expert users (unseen by novice/first time users) to speed up the interaction. Users should be allowed to tailor frequent actions.

- **Aesthetic and minimalist design** – Irrelevant information, or information that is rarely needed, should not appear in the interface. This extra information competes with relevant information.

- **Help users recognise, diagnose, and recover from errors** – Error messages should be expressed in clear plain language. It should precisely indicate the problem and constructively suggest a solution.

- **Help and documentation** – The ideal would be to be able to use the system without documentation. To cater for different user preferences, it may be necessary to provide help and documentation. Such information should be easy to search for, focused on the user's task, list concrete steps to be carried out and not be too bulky.

In the following section these above-mentioned ten heuristics will be used to evaluate the user interface of the first prototype. Although this evaluation method might be considered to be *subjective*, it is believed that valuable insight might be gained from such an exercise. In an attempt to minimize bias from this method, concrete examples were given to indicate whether or not the first prototype complies with a heuristic.

6.3.2.1 Heuristic evaluation of the first prototype

- **Visibility of system status** – The first prototype supports visibility of the system fairly well. A status bar appears at the bottom of every screen. As soon as any task/operation has been completed, the appropriate message appears in the status bar. Examples of these tasks/operations include when a family was found ("Family

found"), when a consultation was successfully stored ("Consultation successfully stored"), when a patient record has been updated ("Patient information updated"), and when a previous illness has been deleted ("Previous illness deleted"). These messages are perceived to appear immediately after the task/operation has been executed.

- **Match between system and the real world** – The starting point for developing the first prototype was a copy of a manual clinical patient record – a very familiar concept to all general practitioners. These documents served as a guide for the type of information to be included in the electronic version of an EPR. The terminology used also originated from these documents. The frequent walkthrough evaluation sessions held with a physician, played a vital role in "getting the medical terminology right" from the start. The terminology, therefore, matches the real world terminology.

  Another aspect that maps the real world onto the system was basing the prototype on the SOAP model. As has been mentioned before, the SOAP model is an internationally accepted model for recording consultations, and most physicians are familiar with the model. The results of the questionnaires that were sent out to general practitioners (Chapter 4) indicated that this model is generally used by general practitioners in South Africa. Bearing these facts in mind, the conclusion is made that the SOAP model facilitates the match between the system and the real world to a great extent.

- **User control and freedom** – The first prototype does not provide for explicit *undo* and *redo* functions. This must be perceived as a limitation. When making a mistake (e.g. typing error), the user is expected to return to the specific field and use the Backspace or arrow-keys to rectify the problem. The user is, however, allowed to make changes to the Family and Patient screens any time.

When entering a consultation via the SOAP screens, the user is allowed to return to screens and make changes to the information. The provision, however, is that the "To patient" button has not been pressed yet, which will prohibit any further changes. This inability to go back to a specific consultation after it has been finalised and saved, was, however, specifically built in for the physician's medico-legal protection.

The first prototype does not fair too well with regard to user freedom. The user is forced, with the placement of the option buttons, to follow a certain path when creating a medical note. The physician has to, for example, go through the Consultation screen in order to get to the Plan screen. When selecting the Close button by accident on the History screen, the user is returned to the Patient screen without an option to finish entering the specific consultation. This results in many "dummy" consultations that are meaningless.

Broadly seen, the first prototype still needs work as far as user control and freedom are concerned.

- **Consistency and standards** – When considering aspects like system feedback, screen layout, and general functioning procedures, the first prototype seems to comply with the consistency and standards condition very well. Such a statement needs elaboration: when working with the system, not one search, save, edit or delete action was detected where the system did not respond with an appropriate message on the status bar. Considering the screen layouts, all the OK, Cancel, Clear and Close buttons are consistently placed at the bottom right-hand corner of each screen. The buttons that serve as "pathways" to other screens are all placed on the top left-hand corner of the screens. Relevant information on screens is similarly grouped together throughout the system. The way that the grids function, can be illustrated as an example of consistency and standards followed in the functioning of the system. Throughout the first prototype a record in a grid is

selected by double-clicking on it. This double-click event will move the selected item to an edit field where further manipulation (edit or delete) can be conducted.

In contrast to the above-mentioned aspects of the first prototype, there are certain aspects of the system that do not comply with the consistency and standards condition. Although the application of colour is generally consistent (teal-coloured screens and white input fields), the colour-use for grids is anything but consistent. On the Family and Patient screens, the grids are white. On all the other screens, Aqua is used for the grids. (The fact that the Allergy grid is red was done on purpose to attract the physician's attention immediately).

The appearance of screen components also shows tendencies of inconsistency. On some screens (Consultation, Side room examination, and Assessment) "bitbuttons"[4] are used, while on other screens (History, General appearance, and Systemic Examination) normal buttons are used for the same actions. The OK button, therefore, sometimes has a ✔ associated with it and sometimes it is only identified with the word "OK". Similarly a ✖ is sometimes associated with the Cancel button, and sometimes not.

A serious inconsistency problem arises when the date format is considered. When entering the birth date, for example, a format of "dd/mm/yyyy" is required. On the previous history screens, a format of "yyyy/mm/dd" is required.

All these examples indicate that serious consideration still needs to be given to consistency and standard aspects of the first prototype.

- **Error prevention** – Throughout the first prototype the user is provided with lists of possible valid choices to choose from. These choices are provided in combo box components. This relieves the user from typing certain options, with the danger of typing errors that might result in system errors. Examples of these lists are titles,

[4] A button component with a picture/visual symbol associated with it.

languages, marital status, and types of consultations. Similarly, when the user attempts an update action, he/she is required to first select the item that needs changing from the grid. As mentioned before, this will result in the specific item being copied to an edit field where the necessary changes may be made. This ensures that the correct item is changed.

The confirmation that is required when an item is deleted, is another way of preventing errors. Confirmation when leaving the system is, however, not provided for. This feature could much enhance error prevention. Behind the scenes controls are also built in to prevent the allocation of duplicate family account numbers and patient identification numbers.

These examples indicate that an effort was made to prevent errors from occurring in the first prototype.

- **Recognition rather than recall** – In addition to error prevention, providing the user with valid choices in the form of combo box lists or grids also serves as a method to facilitate recognition rather than recall. The fact that a newly added previous illness, for example, is immediately listed in the grid on the Previous illness screen, reminds the user that the illness was indeed added. The same principle applies to the deletion or changing of such an illness.

  Next to every date field the user is reminded of the date format to use. This removes the memory burden of remembering what the format was. On the Assessment screen the user has a choice to view the problem list in different ways. One way, for example, is to view all the active problems between a date range. To facilitate the entering of the dates, the user is presented with a graphical calendar. By simply selecting a day from the calendar (and ensuring that the correct year and month is used), the user is relieved from the memory burden of remembering the date format to use.

The physician also does not need to remember the systems to check during the Systemic Examination or the General Appearance options to investigate. These systems and options are presented to them and they simply can go down the list and enter information where applicable.

Another (light-hearted) example of recognition rather than recall is that the user needs only to remember his/her identification number and not his/her birth date as well! When entering the identification number and pressing the TAB-key, the date of birth is automatically entered in the appropriate field. The messages appearing on the status bar also serves as a reminder of the last action performed, rather than having to remember the last action.

Areas where the first prototype still comes short with regard to recognition, is the absence of hints[5], the fact that the user has to retype the residential address on the Patient screen even though it might be identical to the postal address typed in on the Family screen, and the fact that no help facility exists. The latter, however, involved a conscious decision not to provide a formal help facility, as this is a prototype system in contrast to the "real thing".

- **Flexibility and efficiency of use** – The first prototype provides for flexibility and efficiency of use in the form of button accelerator keys. A letter on each button (generally the first letter of the button caption unless the letter has already been used by another button on the screen) is underlined. This implies that the user may press down the ALT-key in conjunction with the underlined letter on the keyboard to activate the button event in comparison to using the mouse. No further provision for flexibility and efficiency of use could be identified.

- **Aesthetic and minimalist design** – As a result of the fact that the information contained on the screens of the first prototype was identified as being important by

[5] A hint appears on the screen regarding the function of the screen component as soon as the mouse cursor is moved over the component in question.

the physician involved in the cognitive walkthroughs (section 6.3), it is not possible (at this stage) to determine whether unnecessary information is contained in the prototype. The task analysis (section 6.3.3.2) will throw some light on this matter.

- **Help users recognise, diagnose, and recover from errors** – The error messages provided in the first prototype are relatively simple. For example, when searching for a non-existing account number on the Family screen, the error message "The account number you entered does not exist" will appear in a modal dialogue box, and "Family not found" in the status bar at the bottom of the screen. More attention should, however, be given to constructively suggest a solution in the message.

- **Help and documentation** – With the knowledge of a few basic system features (for example that the TAB-key is used to move from field to field, that grids need to be double-clicked in order to modify items listed on it, etc.), the system appears to be simple enough for a physician to use (or at least play around with!) without too much extra help. The eventual EPR system should, however, make provision for an on-line help facility, as well as a written user guide. (A "Getting started" section appears to be very popular). Being a prototype, and therefore a *means to an eventual goal* (an acceptable EPR system), the effort of writing an extended Help facility was deemed to be impractical.

Although performed by the designer (with the possibility of subjectivity) the heuristic evaluation turned out to be an extremely fruitful exercise. Being forced to evaluate the system in a structured and methodical way (as suggested by heuristic evaluation), many problems (and positive aspects) were highlighted in the process – aspects that were previously overlooked. Although this evaluation indicated that the first prototype was on the right track and had some good features, the general impression was left that there was still some work to be done!

Although one cannot argue against the validity and usefulness of performing a heuristic evaluation during system design (as is generally done according to the literature), much can be said to encourage the performance of this type of evaluation on a "complete" system, as was done here regarding the first prototype. Valuable insight can be gained with respect to improvements that need to be brought about when considering a next prototype. Where certain parts of the system are tested against a list of heuristics during the design phase, a much better perspective on the system as a whole can be gained when doing these tests after system completion. This brings the heuristic of consistency to mind. Although consistency should be born in mind throughout the design process, a system can only truly be evaluated for consistency after the system has been completed. Therefore, where heuristic evaluation during system design is seen as a goal to work towards, it is seen as a test for adherence to this goal when performed on a complete system. In the light of the above-mentioned arguments, the author would strongly recommend the performance of heuristic evaluation on complete systems in addition to its application during the design process, especially where prototype design is concerned.

6.3.3 Usability testing

Dix *et al.* [1998] state that the ultimate test of a product's usability is based on measurements of users' experience with it. This measurement aspect is introduced in the term *usability engineering* [Whiteside 1988; Nielsen 1992a; Nielsen 1992b]. The focus in usability engineering (that is, where the actual measurements are taken) lies in the actual user interface since the user's experience with an interactive system is at the physical user interface. The danger associated with usability engineering is that much of the work that is accomplished in interaction involves more than just the features of the systems used to perform that work. In reality the whole functional architecture of the system and the cognitive capacity of the users should be observed in order to arrive at meaningful measures. It is, however, extremely difficult to derive measurements of activities beyond the physical actions in the world. Therefore usability engineering is limited in its application.

Having noticed its limitations, usability engineering still played a useful role in the usability testing of the first prototype. Observational techniques were used to obtain the measured results of the users' experience with the first prototype system. In order to decide what to measure, usability engineering principles were used. After obtaining the observed data, empirical methods were applied to add meaning to the measured results.

Shneiderman [1998] indicates that competitive usability testing can be used to compare a new interface to previous versions. Dix *et al.* [1998] list one of the possible applications for empirical evaluation methods to be a comparison of one system to another to determine which one is best (with respect to specified aspects). In order to apply empirical methods in competitive usability testing in this thesis, the same empirical tests should be performed on the second prototype as well (Chapter 8 and 9). Meaningful hypotheses, as well as deductions can only be made when the two prototypes are compared to each other. The results of the empirical tests of the first prototype will, therefore, not be presented in this chapter. The complete empirical results with a discussion will be presented in Chapter 9.

Before commencing with the discussion on the usability testing procedures, it is important to note that the author could not obtain satisfactory guidance from the utilized literature on how to perform a comparative empirical usability evaluation ideally suited to the specific circumstances. Much has been written on the theory and application of usability evaluation in general, and even of evaluation in primary health care. It has often been suggested that usability testing should include the measuring of specific criteria, but no stipulation on how to go about it could be found. Therefore, all that remained to work on was the suggestion!

The usability procedures that were followed for the purpose of this thesis, and that are discussed in this section, are therefore the author's own interpretation of how such a comparative usability evaluation could be undertaken. The boundaries between the different methods that were applied are not always clear, as a combination of usability tests, usability engineering, observational techniques, task analysis, and even heuristic

evaluation (if so interpreted) were used. An attempt will, however, be made to clarify the boundaries as far as possible. Despite the "hodge-podge" of methods used, it was an enlightening experience to combine and utilize closely related areas in such a way to suit the specific circumstances at hand and to eventually be able to draw meaningful conclusions regarding the usability of the prototypes.

In what follows the usability testing procedures that were followed will be outlined. Qualitative evaluations for usability principles identified will be presented, as well as an indication of the type of quantitative evaluation that would be conducted for each usability principle. The chapter will be concluded with a task analysis for the first prototype.

6.3.3.1 **Usability testing procedures**

To attempt to measure usability, it was necessary to first determine which usability aspects of an interactive system should be measured. It was decided to use the framework of the usability properties as identified by Dix *et al.* [1993] and adapted by De Wet [1994]. These usability principles are summarised in Table 6.2. (Eason [1984] also presents a framework for usability studies as an alternative to the framework chosen for this thesis.).

For each usability principle a qualitative evaluation was first performed. It might be argued that these qualitative evaluations are nothing more than a repetition of the heuristic tests already performed. One of the motivational factors for this argument might be that in some cases the qualitative evaluation was done from the designer's point of view (as was the case with the heuristic evaluation), and not from the user's point of view, as is generally the case in usability testing. Although these arguments might have some truth associated with them, the author is of the opinion that the value gained from these qualitative evaluations was of such a nature that they were well worth performing. These evaluations may be viewed as extensions to heuristic evaluation – they were performed in much more detail, covered much more ground and were performed on a relatively low system-level. During these evaluations insight was gained regarding

Usability principles affecting Learnability	**The ease with which new users can begin effective interaction and achieve maximum performance**
Predictability	Support for the user to determine the effect of future action based on past interaction history
Synthesizability	Support for the user to assess the effect of past operations on the current state
Familiarity	The extent to which a user's knowledge and experience in other real-world or computer-based domains can be applied when interacting with a new system
Generalizability	Support for the user to extend knowledge of specific interaction within and across applications to other similar situations
Consistency	Likeness in input-output behavior arising from similar situations or similar task objectives
Interaction metaphors	Support for the user to teach new concepts in terms of ones which are already understood
Visual clarity	Eliminating every pixel not serving user-important data, muting minor visual elements, removing distracting patterns, ending clutter, avoiding fussy redundancy in visual signals and continually directing screen design toward a clean, sharp, precise user interface
User guidance and support	The degree to which a system allows users to learn as they use it
Enjoyability	To be used without reluctance, a system must be enjoyable to its users. It is a subjective matter depending on complex and interacting factors
Conceptual (mental) models	The facilitating of the forming of an idea in the user's mind of what a system does and how it does it
Usability Principles affecting Flexibility	**The multiplicity of ways in which the user and system exchange information**
Dialogue initiative	Allowing the user freedom from artificial constraints on the input dialogue imposed by the system
Multi-threading	Ability of the system to support user interaction pertaining to more than one task at a time
Task migratability	The ability to pass control for the execution of a given task so that it becomes either internalised by user or system or shared between them
Substitutivity	Allowing equivalent values of input and output to be arbitrarily substituted for each other
Customizability	Modifiability of the user interface by the user or the system
Control	Providing the user with a sense of being in control of the system at all times, as well as providing choices where possible

Usability Principles affecting Robustness	**The level of support provided to the user in determining successful achievement and assessment of goals**
Observability	Ability of the user to evaluate the internal state of the system from its perceivable representation
Recoverability	Ability of the user to take corrective action once an error has been recognised
Responsiveness	How the user perceives the rate of communication with the system
WYSIWYG	Everything the user sees on the computer screen, tells him what state the system is in – What You See Is What You Get
Task conformance	The degree to which the system services support all of the tasks the user wishes to perform and in the way that the user understands them

Table 6.2 A summary of Usability Properties [Dix 1993, De Wet 1994]

positive as well as negative aspects surrounding the first prototype that would have been totally overlooked had they not been performed. Although many of the comments made during this qualitative evaluation process originated from the designer's perspective, the mere nature of the usability properties forced the designer to regard the system from the user's point of view. The designer so to speak "stepped into the shoes of the user". In many cases the users' input gained through the query techniques and the post-task walkthroughs were, in fact, used as proof of the system's conformance/failure as far as a specific usability principle was concerned. Therefore, instead of being satisfied with only quantitative evaluation methods (as will be discussed shortly), it was decided to include the qualitative evaluations as a result of their valuable contribution to the evaluation process.

Where possible (and appropriate), quantitative evaluation methods were deployed. In these cases measurement criteria for the usability properties were identified by applying the theory of usability engineering. How were these criteria measured? In order to accommodate all of these criteria, it was decided to compose three tasks that would eventually be given to the subjects (physicians taking part in the evaluation process) to perform. The reason for composing three tasks instead of one was a practical one. It

would have been impossible for the evaluator to, for example measure the duration of the consultation as well as the duration of an error correction exercise simultaneously. Therefore, the criteria were divided among the three tasks in a practical and meaningful way to facilitate the observations that were to be undertaken. These three tasks were presented to the subjects on a task sheet of which a copy is presented in Appendix G.

In order to assist the evaluator in performing the "paper and pencil" observations, an evaluation sheet was designed (Appendix H). This evaluation sheet consisted of three pages – one for every task that the user had to perform. For every task (on every page), the criteria that had to be measured were listed. The evaluation sheet was also expanded to capture data that would be used in the task analysis that still had to be performed. (The task analysis will be discussed later in the chapter).

To explain how the observations were physically performed, the following discussion will be organised under the headings Subjects, Preparation, and Evaluation sessions:

- **Subjects** – Referring to the choice of subjects, Dix *et al.* [1998] stated that subjects should be chosen to match the expected user population as closely as possible. The testing of actual users would be ideal. If this was not possible, their experience with computers in general, as well as their experience or knowledge of the task domain should be similar.

  Ten physicians were recruited as subjects. If they were not general practitioners practising at the time, they had done so before, or were at the time physicians associated with the Department of Family Medicine at the University of the Orange Free State. The evaluator was satisfied that all of them were experienced physicians capable of bringing their medical expertise to the evaluation session.

  A second question that arises when considering subjects for evaluation, is the size of the sample chosen. On this issue Dix *et al.* [1998] admit that the size is often determined by pragmatic considerations, for example the availability of subjects.

This was a main concern, as general practitioners willing to spend time on evaluating prototype systems amidst their extremely busy schedules, are a scarce commodity. Where a rough sample size of at least ten subjects is recommended, the eventual sample size of ten was deemed to be sufficient regarding the difficult circumstances of finding subjects.

- **Preparation** – Given the fact that learning is involved in this evaluation method, a "within-groups" design [Dix 1998] was used in which each subject performed using both prototypes. In order to avoid transfer of learning (from the first to the second prototype) the subjects were divided into two groups of five each. Each group started the evaluation with a different prototype. Five of the subjects, therefore, were given a set of installation disks for the first prototype EPR system, along with detailed installation instructions (Appendix I) and a document containing a detailed example consultation (Appendix J). (The other five were handed the second prototype first at a later stage). Following the steps indicated in the example consultation, the subjects were guided through the prototype and exposed to its functionality. The subjects were given instructions to do the following:

  - Install the program
  - Work through the detailed consultation example
  - Create 2 new families
  - Create 2 new patients
  - Create 8 different consultations of differing complexity.

  They were requested to make an appointment for the evaluation session as soon as they had completed these tasks. These procedures were followed in order to attempt to place all the subjects on equal footing as far as experience with the prototype was concerned (none of them had worked with the prototype before).

- **Evaluation sessions** – The evaluation sessions were conducted on a one-to-one (evaluator and subject) basis. They took place in either the evaluator's or the subject's office, according to the subject's preference.

The subject was handed the above-mentioned task sheet and was requested to perform the three tasks, using the first prototype. The first task was to create a medical note for a specific patient and the second task to add, edit, and delete previous illnesses, injuries, operations, etc. for the specific patient. The third task was to create a medical note, but before finalising the note, the subject had to correct a mistake made earlier in creating the specific note. Before commencing, the whole process as well as the tasks to be performed, were explained with care. It was stressed that it was the system, and not the subject, which was the "object under scrutiny".

As the subject started performing the tasks one by one, the evaluator was ready with the previously mentioned evaluation sheet, a pencil, and a stopwatch (paper and pencil observational technique). The different aspects, as can be seen in the evaluation sheet in Appendix H, were noted. To compensate for the limitation of the evaluator's writing speed, especially where the steps that the subjects followed had to be noted, a coding scheme was determined beforehand. Examples include:

T	=	Typing	P	=	Problem occurred
B	=	Button	Cb	=	Select from combo box
Cl	=	Click	Sb	=	Status bar message
DbCl	=	Double-click	TAB	=	Press the TAB key

After the session, post-task walkthroughs (refer to section 6.2.3.2) were held where possible problems were discussed with the subject to clarify the observations. Useful remarks were often made by subjects regarding their experiences with the prototype. Each evaluation session lasted for approximately thirty minutes.

The results of these usability tests, organised along the usability principle framework as discussed in the beginning of section 6.3.3.1, will now be given.

6.3.3.2 Results of usability testing

In presenting the results of the usability testing, a qualitative evaluation will first be given for every usability principle. In the cases where a quantitative (empirical) evaluation was possible, the measured aspects for the specific usability property will be named. The tabular results of these quantitative evaluations, combined with the results of the evaluation of the second prototype, will be presented in Chapter 9. The reader might notice that some of the criteria are associated with more than one usability property. In determining the different criteria, it became evident that in some cases, the same criterion may be used to determine compliance with more than one usability property. As the inclusion of more criteria per usability property could be viewed as added proof (or the contrary) of a prototype's compliance to a property, this overlapping was permitted.

- **Learnability**

  - **Predictability** – In order to ensure the ability of the user to anticipate the actions of the computer and to expect consistent responses to operation and functions, both a qualitative and quantitative evaluation were performed.

    Qualitative evaluation

    When considering button-actions on a computer screen, every type of button should always have the same meaning and effect when pressed. The screens contained in the first prototype, where previous illnesses, injuries, operations, examinations, medication, and allergies are entered, are excellent examples of adherence to the predictability usability principle. On all these screens the OK-button implies saving, the Delete-button implies deleting a history entry, the Clear-button implies clearing all the entry fields and the Close-button implies closing the current screen. Unfortunately this adherence to predictability is not

consistent throughout the prototype. On the General Appearance screen, the OK-button saves the entered information as well as closes the screen.

Other examples of predictability in the first prototype include the use of the Tab-key to move from field to field and the double-click action on grids whenever more detailed information on a particular item are desired.

The first prototype, therefore, partially adheres to the predictability principle.

Quantitative evaluation

Number of times that the user asked for assistance

Number of times that the user expressed frustration

- **Synthesizability** – In order to ensure that the change is seen by the user when an operation changes some aspects of the internal system state, both a qualitative and quantitative evaluation were performed.

Qualitative evaluation

A number of examples can be used to indicate that the property of synthesizability is met quite well in the first prototype. The messages appearing on the status bar to indicate that a change has been saved, a record has been deleted, the selected family has been found, etc. gives the user a clear indication that a change has taken place in the internal state of the system. This aspect will be measured in the quantitative evaluation.

As soon as a consultation has been created for a specific patient, the consultation date simultaneously appears in the grid on the patient screen as part of the patient's previous consultations. In addition to the appropriate message appearing in the status bar, this immediately shows the user that the consultation has been created and he/she can immediately go and look at it again. The same principle applies to the creation of a new patient. When returning to the Family screen, the patient name immediately appears in the dependent grid.

The first prototype, therefore, adheres quite well to the principle of synthesizability.

Quantitative evaluation

Number of times that a message appears in the Status bar

- **Familiarity** – In order to ensure that the user can apply knowledge and experience gained in the use of the manual EPR, both a qualitative and quantitative evaluation were performed.

Qualitative evaluation

The use of the SOAP model as the structure for creating a medical note provides a familiar environment for the physician. The first prototype, therefore, adheres to the principle of familiarity.

Quantitative evaluation

Number of times that the user asked for assistance

Time spent on errors

Number of errors

- **Generalizability** – In order to ensure that the user can extend knowledge of specific interaction with other applications to the interaction with the EPR prototypes, both a qualitative and quantitative evaluation were performed.

Qualitative evaluation

The first EPR prototype has a typical "Windows-feel" about it. Users who have worked in a Windows environment before, should be able to interact with the system. There are, however, aspects that are lacking in the EPR prototype when compared to general Windows applications. These include the lack of cut, copy, and paste functionality, as well as the absence of undo/redo functions.

Another aspect that can influence generalizability of the prototype, is the fact that the TAB key must be used to move from field to field instead of the ENTER key. If a user has grown accustomed to using the ENTER key in the applications he/she has worked with in the past, this might cause a usability problem. This aspect is attended to in the quantitative evaluation.

The first prototype therefore does not comply with the generalizability principle.

Quantitative evaluation

Number of times where *ENTER* was pressed instead of *TAB*

- **Consistency** – As a result of the vast scope covered by the term *consistency*, it is very difficult to measure it in a quantitative manner. It was, therefore, decided to evaluate the first prototype's conformance to consistency in a qualitative way.

Qualitative evaluation

The reader is referred to section 6.3.2.1 where a heuristic evaluation of the first prototype's conformance to consistency was discussed. These aspects are applicable in usability testing as well.

Additionally it may be mentioned that usability testing of consistency can be viewed from three angles, namely [Pangalos 1992]:

- Semantic consistency
- Syntactic consistency
- Physical consistency.

The double-click action on a grid to enable manipulation of the selected item, is an example of the first prototype following *semantic consistency* (meaning of the

elements that make up the interface). All the grids in the first prototype follow the same rules.

Where *syntactical consistency* refers to the words used for a specific command and the appearance of the elements comprising the interface, the reader is again referred to section 6.3.2.1 regarding the colour and "bitbutton" consistency.

Physical consistency refers to the hardware and how it is used, for example which key is pressed for a particular command. The fact that the OK button is always pressed to save a change, and the Clear button always pressed to clear the data entry fields, are examples of physical consistency.

Taking the above-mentioned into account, it is concluded that the first prototype only partially adheres to the consistency usability property.

- **Interaction metaphors** – In determining whether users will be able to learn how to use the first prototype in terms of concepts already known to them, a qualitative evaluation was undertaken.

  Qualitative evaluation

  Applying the SOAP model as a framework for entering a consultation on the computer in the first prototype may be viewed as an interaction metaphor. Apart from that, no depiction of the manual EPR (current real-world situation) could be found in the interface. The first prototype therefore only partially adheres to the interaction metaphor principle.

- **Visual clarity** – In order to ensure that the screens of the first prototype are clear, well organised, unambiguous, and easy to read, a qualitative evaluation was undertaken.

Qualitative evaluation

The Family and Patient screens appear to be cluttered. Taking into account that none of the information pertaining to the personal information of a family or patient can be left out (according to the results of the evaluation forms in section 6.3.1), it is not possible to present fewer items on the screen. The use of grouping to group similar items together, and the placement of the grids on the left-hand side of the screens, alleviates the problem to a great extent.

In cases where additional information would have cluttered the screen, this information was presented on different screens. An example is the Systemic History screen. Although forming part of the history, it would have been very difficult to present the information on the already full History screen in a meaningful way. Instead, a "Systemic History" button was created giving access to the Systemic History screen.

The same principle was applied to prevent cluttering when viewing a previous consultation. This, however, sabotaged the clearness of the design, as it would have had more meaning to see all aspects pertaining to a previous consultation grouped together on one screen.

Therefore it may be concluded that the first prototype only partially adheres to the visual clarity principle.

- **User guidance and support** – A qualitative evaluation was given to discuss the provision of user guidance and support.

Qualitative evaluation

The reader is referred to "Help and Documentation" as discussed in section 6.3.2.1. As a result of the lack of user guidance and support, it may be concluded that this usability principle is not supported in the first prototype.

- **Enjoyability** – It is difficult, if not impossible, to measure whether a person enjoys using a system or not. Because of its subjectivity, enjoyment will be evaluated qualitatively.

  Qualitative evaluation

  When discussing the first prototype with the ten subjects participating in the quantitative evaluation during post-task walkthroughs, it was evident that most of them enjoyed using the system. The impression was, however, formed that the mere fact that it was something new and that it was a system with which they could identify, made it an enjoyable experience. Some functionality hiccups did dampen the enthusiasm in one or two cases. Therefore, the first prototype partially adheres to the enjoyability usability principle.

- **Conceptual (mental) models** – As is the case with enjoyment, it is extremely difficult to measure whether a user formed an *accurate* idea of what the system does and how it does it. Therefore the aspect of conceptual models will be evaluated qualitatively.

  Qualitative evaluation

  As mentioned before, when performing the quantitative evaluations, the participating subjects were handed a set of installation diskettes, installation instructions and an example of a consultation. No demonstration of the prototype was given in any way. The subjects had to explore the system on their own. No phone calls or query was made to the designer that could indicate that any of the ten subjects experienced problems when they started using the system and performed the tasks given. This is seen as an indication that the subjects were able to form a clear cognitive model of what the system does and how it does it. The conceptual model usability property is therefore supported.

- **Flexibility**

  - **Dialogue initiative (pre-emption)** – In order to ensure that the first prototype caters for maximum user pre-emption (user initiates actions towards the system) and minimum system pre-emption (system initiates all the dialogue), both a qualitative and quantitative evaluation were performed.

    Qualitative evaluation

    The first prototype is perceived to be more system pre-emptive than user pre-emptive. The reason for this observation is that the user is not always free to move to certain screens at any given time. When entering a consultation, for example, it is not possible to gain access to the Plan screen from the History screen unless one goes through the Consultation screen first.

    Another example of system pre-emption in the first prototype is the use of modal dialogue boxes[6]. In this case system pre-emption can be perceived as being positive. An example of such a modal dialogue box is where confirmation of deletions is requested. When a certain piece of information is deleted, the user is forced by the system to make very sure that that was the original intention – it therefore serves as a safety measure. There is, however, room for improvement as far as these safety measures are concerned. When leaving the system, a confirmation dialogue box should also be included.

    As a result of the system pre-emption, it is concluded that the first prototype does not support dialogue initiative.

    Quantitative evaluation

    Number of times that the user is prohibited from following a step/path

[6] In a modal dialogue box the user is prohibited from doing anything else but responding to the request in the dialogue box [Dix 1998:136]

- **Multi-threading** – In order to ensure that the first prototype supports user interaction pertaining to more than one task at a time, both a qualitative and quantitative evaluation were performed.

Qualitative evaluation

A windowing application naturally supports a multi-threaded dialogue. While using the EPR prototype, the user may leave the system as is and first read his/her electronic mail messages in another application. Within the EPR system, however, the same principle does not apply. The user has to complete the current consultation before, for example, a new family or patient can be retrieved. It is therefore not possible to handle a telephonic query of another patient with the aid of the EPR while busy entering a consultation for a patient sitting in front of the physician.

Multi-threading is closely related to multi-modality. According to Coutaz [1991], two dimensions of multi-modal systems exist:

- Separate channels of communication can be combined to form a single input or output expression. No proof of the existence of this type of multi-modality could be found in the first prototype.
- Multiple channels may be available, but any one expression may be restricted to just one channel. An example hereof is the provision for the user to use either the keyboard or the mouse. The user may either click on the OK-button or use the shortcut key (Alt-O) to evoke the command from the keyboard. The first prototype does not, however, fully comply with the ideal of being able to use it in its entirety with either the mouse or the keyboard. This aspect is tested in the quantitative evaluation that follows.

From the above it is therefore concluded that the first prototype does not support multi-threading.

Quantitative evaluation

Number of times where keyboard-use was attempted in vain

- **Task migratability** – In order to ensure that certain tasks being preformed by the first EPR prototype are not left completely to the discretion of the computer, both a qualitative and quantitative evaluation were performed.

Qualitative evaluation

A few examples of complying with task migratability can be found when evaluating the first prototype. When the user searches for a family by entering the surname / part of the surname of the family head, the system responds with a list of all possible families that meet the requirements. The system does not choose the most likely – this choice is left to the user.

Another example of task migratability can be found where the system awaits confirmation of a certain action. As mentioned before, a confirmation is expected before information can be deleted. In the first prototype confirmation is, however, not expected in the case where a consultation is stored or where the user leaves the system. These aspects are tested in the quantitative evaluation.

From this qualitative evaluation, it is concluded that the first prototype only partially adheres to the task migratability usability property.

Quantitative evaluation

Number of times where the system asked for confirmation

- **Substitutivity** – In order to ensure that equivalent values of input and output are arbitrarily substituted for each other, both a qualitative and quantitative evaluation were performed.

Qualitative evaluation

The first prototype does not allow for the height of the patient to be entered in either metres or centimetres. Only metres are accepted. In this area, therefore, substitutivity does not apply.

When considering the principle of *equal opportunity,* where the distinction between input and output is blurred, the system does better. Throughout the system, grids are used to display data to the user. If the user intends to modify this information, the specific item in the grid (output from the system) is used as input to the system. By double-clicking on the item it is moved to the appropriate edit fields where the changes may be made. The modified information is then subsequently saved. This aspect is further evaluated during the quantitative evaluation.

The use of defaults may also be considered as equal opportunity. This issue will, however, be discussed when the system is evaluated for its *observability.*

The qualitative evaluation, however, indicates that the first prototype only partially adheres to the substitutivity usability principle.

Quantitative evaluation

Number of times where output on tables were used for input

- **Customizability** – To ensure that the first prototype is modifiable by either the user or the system (or both), both a qualitative and quantitative evaluation were performed.

Qualitative evaluation

Dix *et al.* [1998] draw a distinction between user-initiated modification (adaptability) and system-initiated modification (adaptivity).

The first prototype does not meet the adaptivity requirement. The user interface is, therefore, not automatically customised by the system, based on user expertise or observed repetition of certain task sequences.

As a result of the fact that the eventual EPR system will (hopefully!) be used by a variety of general practitioners, each with his/her own preferences and set ways of performing a consultation, it is essential that the user should be able to customise the system. The first prototype caters for this customisation in a limited manner and there is ample room for improvement. Areas where customisation is used include the addition of possible examinations to appear in the combo box on the Side room examination screen. Another example is the addition/deletion of the examinations used in the Dx section on the Plan screen.

As a means to determine areas where customization is lacking, the quantitative evaluation is applied to determine how many times the user expressed the desire to use a specific option that was not available. The qualitative evaluation, however, indicated that the first prototype does not adhere to the customizability usability principle.

Quantitative evaluation

Number of times where the user would want options / different values

- **Control** – In order to ensure that the user always feels in control of the system, a qualitative evaluation was performed.

Qualitative evaluation

In the first prototype the user does not get the feeling of being in control – the system leads the user into predefined paths. This is best illustrated when entering the clinical information during the consultation along the SOAP model. The system determines which screen to go to and assumes that the physician always handles the consultation in the predefined SOAP order. More work, therefore, is

necessary to provide the user with the sensation of being in control. It is, therefore, concluded that the first prototype does not adhere to the control usability principle.

- **Robustness**

  - **Observability** – In order to determine whether the first prototype is observable by providing enough information on the screen to the user to decide how to continue after an interruption, both a qualitative and quantitative evaluation were performed.

    Qualitative evaluation

    Observability can be discussed in terms of four other principles, namely browsability, defaults, reachability, and persistence [Dix 1998].

    The first prototype conforms to the *browsability* principle by providing the user with a means to view a previous consultation on the screen. The use of grids on the previous history screens to list all the user's previous illnesses, operations, injuries, examinations, medication or his/her allergies, also allows the user to browse.

    Defaults can be categorised into static (defined within the system or acquired during initialization) and dynamic (computed by the system as a result of previous user input) defaults. Only one example of a static default could be found in the first prototype, namely the displaying of the current date and time as the consultation date on the History screen. The dynamic default example found is the automatic display of the patient's date of birth after entering his/her identification number. Possible "candidates" identified for default values include the postal address, the type of consultation, first/follow-up consultation, the date associated with the problems on the problem list, and the display of the patient's age as soon

as his/her date of birth is known. The utilisation of defaults will be further investigated in the quantitative evaluation.

Reachability refers to the possibility of navigation through the observable system state. As this principle is closely related to recoverability, it will be addressed later in this section.

Persistence refers to the duration of the effect of a communication act and the ability of the user to make use of that effect. The messages appearing in the status bar, as discussed previously, comply with the persistence principle and will be further pursued with quantitative measures.

Taking the above-mentioned into account, it is concluded that the first prototype only partially adheres to the observability principle.

Quantitative evaluation

Number of static default values on the screen

Number of dynamic default values on the screen

- **Recoverability** – In order to ensure that the user is able to take corrective action once an error has been recognised, both a qualitative and quantitative evaluation were performed.

Qualitative evaluation

Reducing the likelihood of errors forms part of recoverability. Ways in which the first prototype attempts to prevent errors is by validating new account numbers and patient identifications numbers to ensure unique values, confirmation for deletion, and the presentation of choices to users in combo boxes (this facilitates the notion of recognition rather than recall). More fine-tuning with regard to input values (for example valid dates, valid patient lengths, and weights) is still necessary.

Recovery can be forward or backward [Dix 1998]. *Forward recovery* involves the acceptance of the current state and working one's way to the desired state. The first prototype does, although in a cumbersome way, provide for forward recovery. When considering leaving out a part of the main complaint on the History screen and remembering to add it while on the Plan screen, the user is permitted to retrieve his/her steps by closing the previous screens visited until the History screen is reached. The time it takes to make a correction and the number of steps involved will form part of the quantitative evaluation. Other examples of forward recovery are the provision of Clear-buttons on the screen (to clear the edit fields) and the provision of Delete-buttons on the previous history screens.

Backward recovery involves an attempt to undo the effects of previous interaction in order to return to the previous state before proceeding. The first prototype does not support undo and redo functions.

The principle of *commensurate effort* states that if it is difficult to undo a given effect on the system state, it should have been difficult to reach that state in the first place [Dix 1998]. This principle may be applied to the fact that a user is not allowed to change a consultation once it is stored (the assumption is made that some effort has gone into creating the consultation in the first place). It has been mentioned before that this is done for medico-legal purposes.

The qualitative evaluation, therefore, indicates that the first prototype only partially adheres to the recoverability usability principle.

Quantitative evaluation

Time duration to make a correction

Number of steps necessary to make a correction

- **Responsiveness** – In order to ensure that the user perceives the rate of communication with the system as acceptable, a qualitative evaluation was performed.

Qualitative evaluation

The feedback received from the presentation and demo of the first prototype to general practitioners, as well as informal feedback from the subjects participating in the quantitative evaluation, indicated that no problems were experienced with response time. The duration of time needed by the system to express state changes to the user is perceived as being instantaneous. It was not possible to time response time within the system, as it was too quick for a human to handle a stopwatch. It must, however, be born in mind that the increasing number of patients in the database might have an effect on response time in future – an aspect that should be carefully monitored. In the mean time, however, it may be concluded that the first prototype adheres well to the responsiveness usability property.

- **WYSIWYG** – In order to ensure that what the user sees on the screen "tells the whole story", a qualitative evaluation was performed.

Qualitative evaluation

Frenkner [1990] stated that in a word-processing context, WYSIWYG implies that the document is shown on the computer screen as it will look on paper. Although a printing function has not yet been included in the functionality of the first prototype, certain assumptions may be made regarding the future printing facility. Currently the user is presented with three screens when viewing a previous consultation. These previous consultations represent the clinical notes, which most of the practitioners would prefer to be able to see on paper as well (Chapter 4). It would be impractical (and impossible!) to present the clinical note on paper as it currently appears on three computer screens. Therefore, what the user sees on the computer screen, would not be similar to what he would see on

paper. The conclusion may be drawn that another way should be found to represent the clinical note (previous consultations) on the screen. The principle of WYSIWYG is, therefore, not adhered to in the first prototype.

- **Task conformance** – In assessing the first prototype's conformance to all the other usability principles, qualitative and quantitative evaluations were performed. In order to ensure that the first prototype services and supports the tasks the user wishes to perform (in this case, creating patient consultations), as well as the way the user understands them, a qualitative evaluation seemed inappropriate. Qualitatively one could basically ask a user whether he/she could perform his/her task, with a resultant yes/no reply – this does not say much. To identify measurable criteria to test for task conformance (quantitative evaluation) was also difficult, as many factors could contribute towards task conformance. One criterion that could be measured and had the potential of being quite meaningful in a comparison between the two prototypes, is the time duration to create a consultation. The results of this quantitative evaluation will be presented in Chapter 9. The consultation duration, however, only addressed a small fraction of the scope of task conformance. Therefore the solution seemed to be the undertaking of a task analysis. The first prototype's compliance to the task conformance principle would be evaluated in a scientific, methodical, and thorough manner.

Task analysis is a very specialised concept. To cover it in-depth would fall outside the scope of this thesis. This section, therefore, will give a broad overview on task analysis and then portray the results of the steps taken performing the task analysis.

Task analysis

Although many variations on the definition exist, task analysis may be defined in the broadest sense as *the study of what a user is required to do in terms of actions and/or cognitive processes to achieve a task* [Van Dyk 1999].

The benefits associated with performing task analysis include the following [Maguire 1997]:

- It provides knowledge of the tasks that the user wishes to perform
- It is a reference against the value of the system functions and features can be tested against
- It is a cost-saving exercise – failure to allocate sufficient resources to the task analysis activity increases the potential for costly problems arising in later phases of the development
- It makes it possible to design and allocate tasks appropriately and efficiently within a new system
- The functions to be included within a system, as well as the user interface, can be more accurately specified.

Dix *et al.* [1998] list three approaches to task analysis, namely task decomposition, knowledge-based techniques, and entity-relationship based techniques. Task analysis for knowledge description (TAKD) is a knowledge-based technique for task analysis that generates a hierarchical description of tasks – the task descriptive hierarchy (TDH) – and translates these into a set of knowledge representation grammar (KRG) sentences. Additional to using TAKD to describe tasks as part of producing a requirement specification, it can be used for evaluation purposes once a computer system or prototype has been built [Diaper 1989]. This, as well as the fact that it forces an inherently user-centered perspective, were the main reasons for selecting TAKD as task analysis approach for this thesis. The four stages of a TAKD analysis cycle, as summarised by Van Dyk [1999:79], is presented in Table 6.3.

The rest of the section on task analysis will be discussed under the following headings:

- Problem area
- Task problem statement
- Task observation and data collection
- Task activity list (AL) and prose description
- Selection of specific objects and specific actions
- Task descriptive hierarchy (TDH)
- KRG sentences
- KRG sequence analysis
- Discussion of task analysis results.

STAGE NR.	STAGE	STAGE DESCRIPTION
1	Construction of an activity list (AL)	This is a prose description of the set of tasks that are observed. It is also sometimes referred to as a task protocol. The input is generally a video recording of task execution and a post-task walkthrough, although task-oriented interviews can also be used.
2	Selection of Specific Objects (SO) and Specific Actions (SA)	These are the lowest levels of objects and actions that will be subjected to analysis. They are directly selected from the AL where the SA are shown in square brackets [], and the SO in rounded brackets ().
3	Construction of the TDH	This represents each line from the AL by a single depth first traversal from a single leaf note (with at least one SO), to the single top node.
4	(a) Specification of Specific and Generic KRGs	This is the main output from a TAKD analysis and describes a single traversal from the leaf node to the top node. A uniqueness rule applies to each sentence.
	(b) Specification of Task Sequence Representation	These are lists of repeated sequences from all levels of generification.

Table 6.3 Summary of the four stages of a TAKD analysis cycle

- Problem area

  The problem area is the creation of a medical note during a patient consultation by using the first EPR prototype system.

- Task problem statement

  Concise problem statement – Create a consultation (clinical note) for a patient using a general practice-related Electronic Patient Record (EPR) system.

  Detailed problem statement – Retrieve a family and patient from the general practice-related Electronic Patient Record (EPR) system, create a consultation (clinical note) for the patient and thereafter close (log out of) the system.

- Task observation and data collection

  The reader is referred to the usability testing procedures as were discussed in section 6.3.3.1. The data for the task analysis was also collected during these evaluation sessions while applying the same methods as discussed in section 6.3.3.1.

- Task activity list (AL) and prose description

  The last-refined version of the task AL is presented in Table 6.4. The format is adapted according to the method described by Van Dyk [1999]. It is also of importance to note the following:

  - All of the computer-generated actions visible on a page were included in the AL, even if these actions were not used in the specific task used for the task analysis purpose

Line	Screen	Prose description	Specific Object() and Action[]
1		Title: EPR system consultation creation	
2			
3	Families	Computer displays families page	(computer) [display1] (page-families)
4	Families	Computer prompts for creating a new family via new family button	(computer) [prompt1] (page-families) (button-newfamily)
5	Families	Computer prompts for creating a new patient via new patient button	(computer) [prompt2] (page-patients) (button-newpatient1)
6	Families	Computer prompts for account number to search on	(computer) [prompt3) (consultation-accountnumber)
7	Families	Computer prompts for surname to search on	(computer) [prompt4] (consultation - surname)
8	Families	Computer prompts for dependant on grid	(computer) [prompt5] (grid- consultation - dependant)
9	Families	Computer prompts for search button press	(computer) [prompt6] (button-search)
10	Families	Computer prompts for clear button press	(computer) [prompt7] (button-clear1)
11	Families	Computer prompts for OK button press	(computer) [prompt8] (button-ok1)
12	Families	Computer prompts for close button press	(computer) [prompt9] (button-close1)
13	Families	User enters account number	(user) [enter1] (consultation -accountnumber)
14	Families	User double-clicks on dependant grid	(user) [dbl-click] (grid- consultation - dependant) (consultation -dependant)
15	Patients	Computer displays patients page	(computer) [display2] (page-patients)
16	Patients	Computer prompts for navigation to history page via history button	(computer) [prompt10] (page-history) (button-history)
17	Patients	Computer prompts for navigation to	(computer) [prompt11] (page-assessment)
18	Patients	assessment page via assessment button	(button-assessment1)
19	Patients	Computer prompts for creating a new patient via new patient button	(computer) [prompt12] (page-patient) (button-newpatient2)
20	Patients	Computer prompts for previous appointments on grid	(computer) [prompt13] (grid-consult-previous)
21	Patients	Computer prompts for clear button press	(computer) [prompt14] (button-clear2)
22	Patients	Computer prompts for cancel button	(computer) [prompt15] (button-cancel1)
23	Patients	Computer prompts for OK button press	(computer) [prompt16] (button-ok2)
24	Patients	Computer prompts for close button press	(computer) [prompt17] (button-close2)
25	Patients	User presses history button	(user) [press1] (button-history)
26	History	Computer displays History page	(computer) [display3] (page-history)
27	History	Computer prompts for navigation to examination page via examination button	(computer) [prompt18] (page-examination) (button-examination)
28	History	Computer prompts for main complaint	(computer) [prompt19] (consultation - maincomplaint)
29	History	Computer displays current date and time	(computer) [display4] (consultation - datetime)
30	History	Computer prompts for navigation to previous illness page via illness button	(computer) [prompt20) (page-previllness) (button-illness)
31	History	Computer prompts for navigation to previous operations page via operations button	(computer) [prompt21] (page-prevoperation) (button-operations)
32	History	Computer prompts for navigation to previous injuries page via injuries button	(computer) [prompt22] (page-previnjuries) (button-injuries)
33	History	Computer prompts for navigation to previous examinations page via examinations button	(computer) [prompt23] (page-prevexaminations) (button-examinations)
34	History	Computer prompts for navigation to previous medication page via medicine button	(computer) [prompt24] (page-prevmedication) (button-medicine)
35	History	Computer prompts for navigation to allergies page via allergies button	(computer) [prompt25] (page-allergies) (button-allergies)
36	History	Computer prompts for family history	(computer) [prompt26] (consultation-history)
37	History	Computer prompts for general profile	(computer [prompt27] (consultation-genprofile)
38	History	Computer prompts for navigation to systemic history via systemic inquiry button	(computer) [prompt28] (page-systemichistory) (button-systemicinquiry)
39	History	Computer prompts for OK button press	(computer) [prompt29] (button-ok3)
40	History	Computer prompts for Close button press	(computer) [prompt30] (button-close3)
41	History	User enters main complaint	(user) [enter2] (consultation -maincomplaint)
42	History	User presses OK button	(user) [press2] (button-OK3)
43	History	User presses examination button	(user) [press3] (button-examination)
44	Examination	Computer displays examination page	(computer) [display5] (page-examination)
45	Examination	Computer prompts for navigation to assessment page via assessment button	(computer) [prompt31] (page-assessment) (button-assessment2)

46	Examination	Computer prompts for navigation to plan page via plan button	(computer) [prompt32] (page-plan) (button-plan)
47	Examination	Computer prompts for nature of consultation on drop-down combo box	(computer) [prompt33] (dropdowncombobox-nature)
48	Examination	Computer prompts for first/follow-up on drop-down combo box	(computer) [prompt 34] (dropdowncombobox-first)
49	Examination	Computer displays current consultation date and time	(computer) [display6] (consultation - datetime)
50	Examination	Computer prompts for length	(computer) [prompt35] (consultation -length)
51	Examination	Computer prompts for weight	(computer) [prompt36] (consultation -weight)
52	Examination	Computer displays body/mass index	(computer) [display7] (consultation - bodymassindex)
53	Examination	Computer prompts for abdominal circumference	(computer) [prompt37] (consultation - abdominalcircumference)
54	Examination	Computer prompts for temperature	(computer) [prompt38] (consultation - temperature)
55	Examination	Computer prompts for pulse rate	(computer) [prompt39] (consultation - pulserate)
56	Examination	Computer prompts for respiration rate	(computer) [prompt40] (consultation - respiratoryrate)
57	Examination	Computer prompts for blood pressure	(computer) [prompt41] (consultation - bloodpressure)
58	Examination	Computer prompts for navigation to general appearance page via general button	(computer) [prompt42] (page-gappear) (button-general)
59	Examination	Computer prompts for navigation to systemic investigation page via systemic button	(computer) [prompt43] (page-systemicinvestigations) (button-systemic)
60	Examination	Computer prompts for side room investigation page via side room button	(computer) [prompt44] (page-sideroom) (button-sideroom)
61	Examination	Computer prompts for differential/final diagnosis	(computer) [prompt45] (consultation - diagnosis)
62	Examination	Computer prompts for clear button press	(computer) [prompt46] (button-clear3)
63	Examination	Computer prompts for OK button press	(computer) [prompt47] (button-ok4)
64	Examination	Computer prompts for close button press	(computer) [prompt48] (button-close4)
65	Examination	User opens nature of consultation drop-down combo box	(user) [open1] (dropdowncombobox-nature)
66	Examination	User selects consultation from the drop-down combo box	(user) [select1] (dropdowncombobox-nature) (consultation-nature)
67	Examination	User opens first/follow-up drop-down combo box	(user) [open2] (dropdowncombobox-first)
68	Examination	User selects first from drop-down combo box	(user) [select2] (dropdowncombobox-first) (consultation-first)
69	Examination	User enters length	(user) [enter3] (consultation-length)
70	Examination	User enters weight	(user) [enter4] (consultation-weight)
71	Examination	User presses general button	(user) [press4] (consultation-general)
72	Gen appearance	Computer displays general appearance page	(computer) [display8] (page-gappear)
73	Gen appearance	Computer prompts for general appearance state	(computer) [prompt49] (consultation - gappearstate)
74	Gen appearance	Computer prompts for OK button press	(computer) [prompt50] (button-ok5)
75	Gen appearance	Computer prompts for cancel button press	(computer) [prompt51] (button-cancel2)
76	Gen appearance	User selects general appearance state	(user) [select3] (consultation-gappearstate)
77	Gen appearance	User presses OK button	(user) [press5] (button-ok5)
78	Examination	Computer displays examination page	(computer) [display9] (page-examination)
79	Examination	User presses side room button	(user) [press6] (button-sideroom)
80	Side room	Computer displays side room investigation page	(computer) [display10] (page-sideroom)
81	Side room	Computer prompts for examination	(computer) [prompt52] (consultation-examinations)
82	Side room	Computer prompts for remarks	(computer) [prompt53] (consultation-remarks)
83	Side room	Computer prompts for possible new examinations in grid	(computer) [prompt54] (grid-newexaminations)
84	Side room	Computer prompts for new examination	(computer) [prompt55] (consultation-newexaminations)
85	Side room	Computer prompts for side room investigations in grid	(computer) [prompt56] (grid-sideroominvestigations)
86	Side room	Computer prompts for clear button press	(computer) [prompt57] (button-clear4)
87	Side room	Computer prompts for delete button press	(computer) [prompt58] (button-delete)
88	Side room	Computer prompts for OK button press	(computer) [prompt59] (button-ok6]
89	Side room	Computer prompts for close button press	(computer) [prompt60] (button-close5)

90	Side room	User selects examination from grid	(user) [select4] (grid-sideroominvestigations) (consultation-sideroominvestigations)
91	Side room	User presses OK button	(user) [press7] (button-ok6)
92	Side room	User presses close button	(user) [press8] (button-close5)
93	Examination	Computer displays examination page	(computer) [display11] (page-examination)
94	Examination	User presses assessment button	(user) [press8] (button-assessment2)
95	Assessment	Computer displays assessment page	(computer) [display12] (page-assessment)
96	Assessment	Computer prompts for problem	(computer) [prompt61] (consultation-problem)
97	Assessment	Computer prompts for problem date on drop-down combo box	(computer) [prompt62] (dropdowncombobox-problemdate)
98	Assessment	Computer prompts for outcome	(computer) [prompt63] (consultation-outcome)
99	Assessment	Computer prompts for outcome date on drop-down combo box	(computer) [prompt64] (dropdowncombobox-outcomedate)
100	Assessment	Computer prompts for problems in grid	(computer) [prompt65] (grid-problems)
101	Assessment	Computer prompts for problem viewing options	(computer) [prompt66] (radiobutton-problemview)
102	Assessment	Computer prompts for OK button press	(computer) [prompt67] (button-ok7)
103	Assessment	Computer prompts for clear button press	(computer) [prompt68] (button-clear5)
104	Assessment	Computer prompts for close button press	(computer) [prompt69] (button-close6)
105	Assessment	User enters problem	(user) [enter5] (consultation-problem)
106	Assessment	User opens problem date drop-down combo box	(user) [open3] (dropdowncombobox-problemdate)
107	Assessment	User selects problem date on combo box	(user) [select5] (dropdowncombobox-problemdate) (consultation-problemdate)
108	Assessment	User presses OK button	(user) [press9] (button-ok7)
109	Assessment	User enters problem	(user) [enter6] (consultation-problem)
110	Assessment	User opens problem date drop-down combo box	(user) [open4] (dropdowncombobox-problemdate)
111	Assessment	User selects problem date on combo box	(user) [select6] (dropdowncombobox-problemdate) (consultation-problemdate)
112	Assessment	User presses OK button	(user) [press10] (buttton-ok7)
113	Assessment	User presses close button	(user) [press11] (button-close6)
114	Examination	Computer displays examination page	(computer) [display13] (page-examination)
115	Examination	User enters differential/final diagnosis	(user) [enter7] (consultation-diagnosis)
116	Examination	User presses OK button	(user) [press12] (button-ok8)
117	Examination	User presses plan button	(user) [press13] (button-plan)
118	Plan	Computer displays plan page	(computer) [display14] (page-plan)
119	Plan	Computer prompts for possible Dx investigations in grid	(computer) [prompts70] (grid-Dxinvestigations)
120	Plan	Computer prompts for new Dx	(computer) [prompt71] (consultation-newDx)
121	Plan	Computer prompts for adding new Dx via add new dx button	(computer) [prompt72] (button-newDx)
122	Plan	Computer prompts for selecting Dx	(computer) [prompt73] (arrow-Dx)
123	Plan	Computer prompts for navigation to prevexamination page via results button press	(computer) [prompt74] (page-prevexaminations) (button-results)
124	Plan	Computer prompts for Rx	(computer) [prompt75] (consultation-Rx)
125	Plan	Computer displays not implemented yet dialog box	(computer) [display15] (dialogbox-Rxnotimplemented)
126	Plan	Computer prompts for dialog box buttons press	(computer) [prompt76] (button-dialogbox-ok)
127	Plan	Computer prompts for Cx	(computer) [prompt77] (consultation-Cx)
128	Plan	Computer prompts for OK button press	(computer) [prompt78] (button-ok9)
129	Plan	Computer prompts for navigation to patient page via to patient button	(computer) [prompt79] (page-patients) (button-topatient)
130	Plan	Computer prompts for close button	(computer) [prompt80] (button-close7)
131	Plan	User enters Cx	(user) [enter8] (consult-Cx)
132	Plan	User presses to patient button	(user) [press14] (button-topatient)
133	Patients	Computer displays patients page	(computer) [display16] (page-patients)
134	Patients	User presses close button	(user) [press15] (button-close2)
135	Families	Computer displays families page	(computer) [display17] (page-families)
136	Families	User presses close button	(user) [press16] (button-close1)

Table 6.4 Activity list for the consultation task for the first EPR prototype

- All the observed human actions were listed
- Computer processing actions are not included in this AL.

- Selection of specific objects and specific actions

The essential task elements are described as specific objects and actions. The specific object list is presented in Table 6.5 and the specific activity list in Table 6.6. In each case the raw list of all the objects and actions from the AL is listed on the left-hand side, while the refined filtered list, where all the objects and actions not relevant to the task were removed, are presented on the right.

Unfiltered specific object list	Filtered and refined specific object list		
computer	agent-computer	page	families
user			patients
page-families			history
page-patients			assessment
page-history			examination
page-assessment			gappear
page-examination			sideroom
page-previllness			plan
page-prevoperation			
page-previnjuries		button	ok
page-prevexaminations			close
page-prevmedication			history
page-allergies			assessment
page-systemichistory			examination
page-gappear			plan
page-systemicinvestigations			general
page-sideroom			sideroom
page-plan			topatient
button-newfamily			
button-newpatient1		grid	consultation-dependant
button-newpatient2			sideroominvestigations
button-clear1			
button-clear2	agent-user	consultation	consultation
button-clear3			accountnumber
button-clear4			surname
button-clear5			dependant
button-ok1			maincomplaint
button-ok2			length
button-ok3			weight
button-ok4			select-dropdowncombobox
button-ok5			nature
button-ok6			first
button-ok7			gappearstate
button-ok8			problem
button-ok9			problemdate

button-close1	diagnosis
button-close2	Cx
button-close3	
button-close4	
button-close5	
button-close6	
button-close7	
button-cancel1	
button-cancel2	
button-delete	
button-history	
button-assessment1	
button-assessment2	
button-examination	
button-plan	
button-illness	
button-operations	
button-injuries	
button-examinations	
button-medicine	
button-allergies	
button-systemicinquiry	
button-general	
button-systemic	
button-sideroom	
button-newDx	
button-results	
button-dialogbox-ok	
button-topatient	
grid-consultation-dependant	
grid-consult-previous	
grid-newexaminations	
grid-sideroominvestigations	
grid-problems	
grid-Dxinvestigations	
consultation-accountnumber	
consultation-surname	
consultation-dependant	
consultation--history	
consultation-maincomplaint	
consultation--genprofile	
consultation--length	
consultation-weight	
consultation-bodymassindex	
consultation-abdominalcircumference	
consultation-temperature	
consultation-pulserate	
consultation-respiratoryrate	
consultation-bloodpressure	
consultation-diagnosis	
consultation-datetime	
consultation-nature	
consultation-first	
consultation-examinations	
consultation-remarks	
consultation-newexaminations	

consultation-newDx consultation-Rx consultation-Cx consultation-gappearstate consultation-problem consultation-outcome consultation-problemdate Dropdowncombobox-nature Dropdowncombobox-first Dropdowncombobox-problemdate Dropdowncombobox-outcomedate radiobutton-problemview arrow-Dx dialogbox-Rxnotimplemented	

Table 6.5 Specific object list for the first EPR prototype

	Unfiltered specific activity list		Filtered specific activity list	
Agent	**Activity**	**Frequency**	**Activity**	**Frequency**
Computer	prompt	80	prompt	80
	display	17	display	17
user	press	16	press	16
	enter	8	enter	8
	select	6	select	11
	open	4		
	dbl-click	1		

Table 6.6 Specific activity list for the first prototype

- Task descriptive hierarchy (TDH)

Creating the TDH is seen as the principle analytical stage of TAKD. All available knowledge about the tasks is used to build a non-sequential hierarchy of general and specific objects and actions [Van Dyk 1999]. Sequential information, as portrayed in the AL, is lost in the TDH, as well as knowledge of the action or object relationships. The TDH derived from the specific object list for the first prototype is presented as Figure 6.1, while the TDH for the specific actions is presented as Figure 6.2.

```
EPR-CONSULTATION
/
/------PAGE-COMPONENT
/       |
/       |-----PASSIVE
/       |       /
/       |       /--------TITLE          page-title
/       |       /--------OTHER          colour, background, text, style
/       |
/       |-----ACTIVE
/               |
/               |----------BUTTON
/               |               /------ TYPE
/               |               /       {-------NORMAL    general, sideroom
/               |               /       {-------PICTURE   ok, close, history, assessment, examination, plan, topatient
/               |               /
/               |               /------ FUNCTION
/               |               /       |-------PROCEED
/               |               /       |       |-------ACTIVATE      ok
/               |               /       |       |-------TERMINATE     close, topatient
/               |               /       |
/               |               /       |-------UNDO                  clear
/               |               /       |
/               |               /       |-------NAVIGATE              history, assessment, examination, plan,
/               |               /                                     general, sideroom
/               |               /
/               |               /
/               |----------GRID
/                               /------STATE
/                               /       |-------SELECTED              consultation-dependant, sideroominvestigations
/                               /       |-------NOT-SELECTED          consultation-dependant, sideroominvestigations
/                               /
/                               /------APPEARANCE
/                               /       {-------POSITION            consultation-dependant, sideroominvestigations
/                               /       {-------COLOUR              consultation-dependant, sideroominvestigations
/                               /       {-------FONT TYPE/SIZE      consultation-dependant, sideroominvestigations
/                               /
/                               /------FUNCTION
/                                       |-------SELECT              sideroominvestigations
/                                       |-------NAVIGATE            consultation-dependant
/
/------CONSULTATION
        /
        /-----SEARCH
        /       |
        /       |--------ACCOUNTNUMBER          accountnumber
        /       |--------SURNAME                surname
        /
        /-----SELECTION
        /       |
        /       |--------NEW                    consultation, dependant
        /       |--------EXISTING               consultation, dependant
        /
        /
        /-----CREATION
                {
                {--------HISTORY               maincomplaint
                {
                {--------CONSULT               nature-select (dropdowncombobox), first-select (dropdowncombobox),
                {                               length, weight, gappearstate, diagnosis
                {--------PROBLEM               problem, problemdate-select (dropdowncombobox)
                {
                {--------PLAN                  cx
```

KEY: / **AND (all of the levels must be included)**

| **XOR (either/or, at least one level, but not more than one)**

{ **OR (could include more than one level, or all of them, but at least one)**

Figure 6.1 TDH for objects for the first EPR prototype

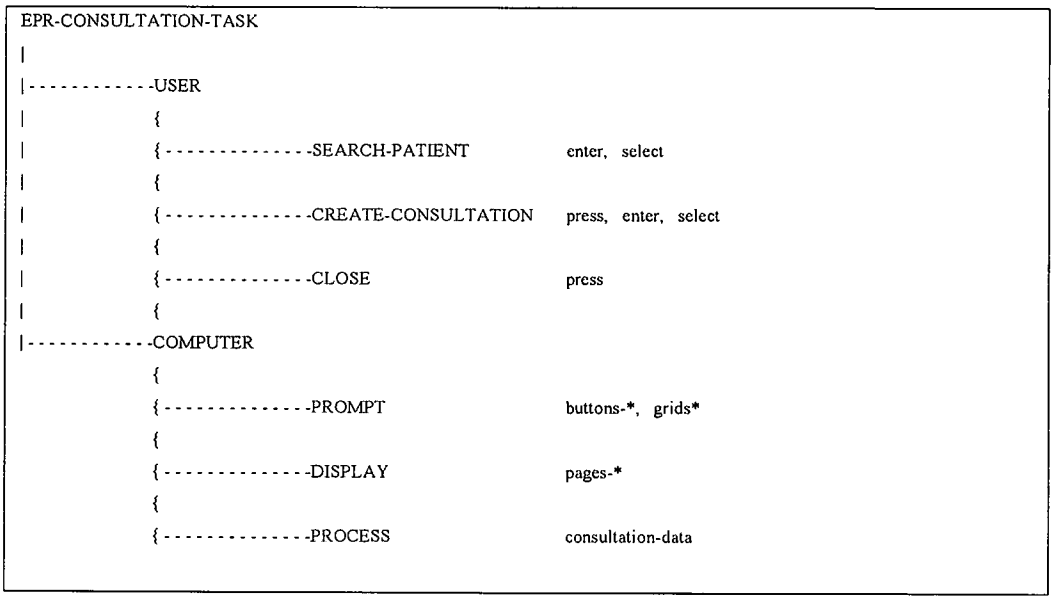


Figure 6.2 TDH for actions for the first EPR prototype

* The asterisk indicates that a variety of buttons, grids and pages are represented.

- KRG sentences

In providing a means for describing the route for each specific object through the TDH, KRG sentences restore the activity-object pairings that were destroyed when creating the TDH from the AL. These relationships are, however, recreated in a more general way [Diaper 1989]. The object and action TDH's are combined to yield a list of complete KRG sentences, each describing a simple task in general terms.

Before generification[7], the following sentences may be derived to describe the three sub-tasks (search patient, create consultation, close system) contained in the detailed problem statement for creating an EPR consultation:

[7] Generification is a process of lower-node removal with the aim of identifying common classes of activity associated with a task [Diaper 1989:125-126].

SEARCH-PATIENT:

EPR-consultation-task (search-patient)	
enter consultation/search(accountnumber)	*accountnumber*
EPR-consultation-task (search-patient)	
enter consultation/search(surname)/	*surname*
EPR-consultation-task (search-patient)	
select grid/function(navigate)/	*consultation-dependant*

CREATE-CONSULTATION:

EPR-consultation-task (create-consultation)	
select consultation/selection(new)/	*consultation*
EPR-consultation-task (create-consultation)	
press button/function(navigate)/	*history*
EPR-consultation-task (create-consultation)	
enter consultation/creation(history)/	*maincomplaint*
EPR-consultation-task (create-consultation)	
press button/function(proceed(activate))/	*ok*
EPR-consultation-task (create-consultation)	
press button/function(navigate)/	*examination*
EPR-consultation-task (create-consultation)	
enter consultation/creation(consult)/	*nature-select, first-select, length, weight*
EPR-consultation-task (create-consultation)	
press button/function(navigate)/	*general*
EPR-consultation-task (create-consultation)	
enter consultation/creation(consult)/	*gappearstate*
EPR-consultation-task (create-consultation)	
press button/function(proceed(activate))/	*ok*
EPR-consultation-task (create-consultation)	
press button/function(navigate)/	*sideroom*
EPR-consultation-task (create-consultation)	

select grid/function(select)/ *sideroominvestigations*

EPR-consultation-task (create-consultation)

press button/function(proceed(activate))/ *ok*

EPR-consultation-task (create-consultation)

press button/function(proceed(terminate))/ *close*

EPR-consultation-task (create-consultation)

enter consultation/creation(consult)/ *diagnosis*

EPR-consultation-task (create-consultation)

press button/function(proceed(activate))/ *ok*

EPR-consultation-task (create-consultation)

press button/function(navigate)/ *assessment*

EPR-consultation-task (create-consultation)

enter consultation/creation(problem)/ *problem, problemdate-select*

EPR-consultation-task (create-consultation)

press button/function(proceed(activate))/ *ok*

EPR-consultation-task (create-consultation)

press button/function(proceed(terminate))/ *close*

EPR-consultation-task (create-consultation)

press button/function(navigate)/ *plan*

EPR-consultation-task (create-consultation)

enter consultation/creation(plan)/ *cx*

EPR-consultation-task (create-consultation)

press button/function(proceed(terminate))/ *topatient*

CLOSE-PROGRAM:

EPR-consultation-task (close-program)

press button/function(proceed(terminate))/ *close*

EPR-consultation-task (close-program)

press button/function(proceed(terminate))/ *close*

During generification, some of the above-listed KRG sentences were combined, or generalised, to produce the final set of user-agent KRG sentences presented in Table 6.7. Eventually five distinct sentences were derived from the sentences above.

EPR-consultation-task (search-patient)
enter (consultation/search/)
EPR-consultation-task (*)
select grid/function/
EPR-consultation-task (create-consultation)
select consultation/selection(new)/
EPR-consultation-task (create-consultation)
enter consultation/creation/
EPR-consultation-task (*)
press button/function/

Table 6.7 Final set of user-agent KRGs for the first EPR prototype

The same principles that were used to reach the results portrayed in Table 6.7 can be applied to reach the final set of computer-agent KRGs, presented in Table 6.8.

EPR-consultation-task(*)
display (page)
EPR-consultation-task
prompt (one-of-three-user-agent-actions)

Table 6.8 Final set of computer-agent KRGs for the first EPR prototype

- KRG sequence analysis

The purpose of KRG sequence analysis and the resultant sequence representation grammar (SRG) is to identify potential macros that might be supplied for users [Diaper 1989].

(1) enter (account-number)
(2) select (dependant)
(3) press (history-button)
(4) enter (main-complaint)
(5) press (ok-button)
(6) press (examination-button)
(7) enter (select-nature, select-first, length, weight)
(8) press (general-button)
(9) enter (general-appearance-state)
(10) press (ok-button)
(11) press (sideroom-button)
(12) select (sideroom-investigation)
(13) press (ok-button)
(14) press (close-button)
(15) enter (diagnosis)
(16) press (ok-button)
(17) press (assessment-button)
(18) enter (problem, problemdate)
(19) press (ok-button)
(20) press (close-button)
(21) press (plan-button)
(22) enter (cx)
(23) press (to-patient-button)
(24) press (close-button)
(25) press (close-button)

Table 6.9 SRG for first EPR prototype

The SRG presented in this section (Table 6.9) was derived from the complete list of KRGs and is presented in a lower level format as in some examples found in task analysis literature. This was done intentionally to emphasize some of the problems as identified in the task analysis and for clarity purposes.

- Discussion of task analysis results.

The task analysis yielded insights on a level that the other evaluation methods described in this thesis could not do. The emphasis was on evaluation from the *user's* perspective when performing a typical task, namely creating a consultation with the aid of the first EPR prototype system. Even at an early stage, when drawing up the AL, possible usability problems could be identified. The discussion to follow, therefore, will be a summarised discussion combining the "informal" insights gained from the exercise and the "formal" results of the task analysis. Some of the aspects mentioned in this discussion may be a repetition of conclusions made during the other evaluation methods described in this chapter, but it was deemed important to show that the task analysis yielded similar results.

The eventual small number of generalised KRGs deducted from a fairly large number of "first effort" KRGs indicates that user and computer actions are repeated considerably in the first prototype. This may be viewed in a positive or in a negative way. Positively it indicates that the user interface is fairly simple to use and easy to learn, as only a small number of different object-action type of relationships exist and need to be remembered. Considering the eventual use of an EPR system, namely in a busy general private practice setting where time is of the essence, and that it is being used in the presence of the patient, these are positive indications. It may also be perceived as a sign that this evaluation method is well suited for the type of task that was examined. Negatively it may be an indication of a lack of creativity in the design of the user interface – the user might perceive the system as being monotonous and "boring to use".

The considerable number of times that the OK-button has to be pressed also drew the attention. Before moving on to another page while entering the consultation information, the OK button needs to be pressed in order for the information to be saved. This seems to be unnecessary effort on the part of the user. During the observations held to obtain the task information used in this task analysis, this was a direct cause of many errors. Some users simply forgot to press the OK button before navigating to the next screen, resulting in lost information.

While *navigation* is mentioned, the user is expected to do a lot of navigation when using the first prototype – some of it unnecessarily. The user may, for example only gain access directly to the Assessment screen from the Patients and the Examinations screens. Similarly, the Plan screen may only be reached via the Consultation screen, and not from the History or the Assessment screens. The task analysis, therefore, confirms what has been mentioned in the heuristic evaluation and rest of the usability testing, namely that the aspect of navigation needs to be further addressed.

Shifting the attention to the Close-button, the task analysis highlighted an inconsistency problem on the Assessment screen. Where the OK-button or navigational buttons are used on other screens to move away from the current screen, the Close-button has to be used on the Assessment screen. This is a possible cause for hesitation and confusion – as has already been evident during the observations conducted.

Still focussing on the Close-button, the sub-task of closing the system (logging off) was highlighted as being cumbersome and inefficient. To close the system, the Close-button has to be pressed three times (the assumption is made that the user wishes to leave the system while being on the Patients screen). The user is forced to retrieve his/her steps from the Patients screen to the Families screen to

the Logon screen (the latter was not included in the task under scrutiny). A single Exit-button placed on at least the Families and Patients screens, would save the user unnecessary effort and simplify the user interface.

The KRG sequence analysis that was performed (refer to Table 6.9) confirms the above-mentioned conclusions, especially the unnecessary use of the OK-button, the navigational problems where the user's freedom of movement is limited, the use of the Close-button on the Assessment screen and the abundant use of the Close-button in order to leave the system.

With the above-mentioned in mind, the task analysis was considered to be time well spent.

6.4 Summary

With the first prototype completed, the evaluation processes and results thereof were discussed.

With so many different evaluation methods, and interpretations of these methods available, careful consideration was needed to decide on the evaluation path to follow. With no suitable guidelines available on how to evaluate the two prototype systems, the author eventually decided to adapt a variety of methods and to apply them in such a way to be able to test the first prototype (and consequently the second prototype) in the most appropriate and thorough manner possible. It therefore implied the author's own interpretation of evaluation methods.

It was decided to evaluate the system from as many angles, perspectives, and viewpoints as possible. First it was evaluated by a group of approximately one hundred physicians with the aid of query techniques (evaluation forms). Then the designer, using a list of ten heuristics, performed a heuristic evaluation. This was followed by usability testing. To perform the usability tests, the author used an existing list of usability properties. The

first prototype was then evaluated according to these principles – first in a qualitative manner and then in a quantitative manner. The latter was deemed to be necessary to substantiate the possible subjectivity that might have crept into the heuristic and qualitative evaluations. Measurement criteria were identified and observational techniques were used to perform these quantitative measurements. The results of the empirical tests that were applied to bring meaning to these quantitative measures, will be presented in Chapter 9, the reason being that the full potential of these methods will only be visible once a comparison between the first an second prototypes has been conducted. A task analysis was also conducted as part of the usability testing. It was used to test the prototype's compliance to the task conformance usability property.

Did these evaluation methods produce the desired results? The author is of the opinion that much more was achieved than was originally expected. The heuristic evaluation forced the designer to re-assess the system from a user interface design perspective. Even if performed after the prototype was completed, and not during the design (as is normally the case), it was extremely useful, as the prototype could be evaluated as a complete unit. In fact, the author would suggest that heuristic evaluation should always be repeated once a system is completed (if it was performed during design). It would ensure that the design goals that were set with the aid of the heuristics during the design, were adhered to.

As far as the usability tests and the subsequent task analysis were concerned, their contribution to the design process is perceived as being indispensable. The usability properties used ensured that an extremely thorough evaluation was performed, covering almost every aspect from a user's perspective. The task analysis was an eye opener. It forced the designer, for example, to consider the need, position, and function of every component on every screen. Many aspects that were never even questioned before, suddenly became the objects under scrutiny. A much lower level evaluation was thus enforced.

Subsequently, the author is of the opinion that, with the available knowledge, the best possible evaluation procedures were followed and that the first prototype was evaluated

"in-side-out"! In Chapter 11 these procedures will be presented as guidelines for future performance of similar evaluations.

The specifications for the second prototype were greatly enhanced by the feedback received from the general practitioners. The evaluations identified the following:

- The second prototype, based on the basic principles of the first prototype, should supply the user with adequate means to reduce typing. This would accommodate the computer-illiterate user and would also save precious time when entering information regarding a consultation.

- The perception of navigating through too many screens should be addressed.

- Aspects that need attention when designing the next prototype are consistency in colour, date formats and appearance of screen components, provision for hints, constructive solutions to error messages, provision for a query facility, extended customisation, defaults, and a WYSIWYG-compliant viewing and printing facility. Saving a consultation should involve a single action, and not the pressing of an OK-button on every screen. Additionally, the process of closing (logging off) the system needs to be streamlined.

By complying with these conditions and using the feedback received on minor issues regarding the system, a major step can be taken in order to present general practitioners in South Africa with an electronic patient record system which will greatly enhance the functioning and utilisation of their practices. The attempt made in order to take this step, will be explained in the following chapter.

Chapter 7

Second EPR Prototype

7.1 Introduction

In Chapter 5 the first EPR prototype system was discussed extensively. In chapter 6 the evaluation results of that system were presented. These evaluation results, based on the presentation of the first prototype to physicians, provided practical guidelines for consideration and implementation in the design of the next prototype system. The results also shed even greater light on what physicians really expect from such a system. This leads the way to a (hopefully) improved version of the system, namely the second prototype.

This chapter will take the reader through the design stages of the second prototype. Feedback from the evaluation of the first prototype, which is implemented in the design of the second prototype, will be highlighted. The chapter will be organised in basically the same way as Chapter 5 in order to facilitate comparison between the two prototypes. This implies that the development environment, the database design, interface issues and the prototype itself will be discussed, in this order. The evaluation process and evaluation results will, however, only be addressed in Chapter 9, the reason being that the second prototype and the HUB system (refer to Chapter 8) will be evaluated simultaneously. The results of this dual evaluation will, therefore, be presented together.

In cases where the design of the second prototype did not differ substantially from that of the first prototype, only the changes will be presented.

7.2 Development environment

The development environment did not alter between the first and second prototype, except for the use of the updated version of C++Builder, namely version 3 for prototype two (refer to section 5.2).

7.3 Database design

The basic principles relevant to the design of the database, for example the use of the E-R model as data model, did not change. The reader is, therefore, referred to section 5.3.1.

7.3.1 Entities

Few changes were made to the entities as described in section 5.3.2. The most significant change made was the exclusion of the History table. The evaluation results of the first prototype indicated that it should be possible to enter/alter the Family History and General Profile fields per patient for every consultation. As these two fields were the only fields contained in the History table and the fact that the History table was not linked to a specific consultation, the change was deemed necessary. The Family History and General Profile were, therefore, included in the Consult table.

Three new tables, namely GeneralA, Modify, and Users were included in the new prototype. Table GeneralA was necessary because of the request for more space to enter the General part of the General Appearance information on the system.

The Modify table contains the modifications to existing consultations. In order to comply with medico-legal requirements, a physician should not be able to tamper with medical notes after the consultation has been concluded. If, however, a change or addition is necessary, this additional information can be entered in a separate table, linked via the consultation date to the consultation it has a bearing upon.

The Users table begins to address the issues of access control and security. Before a user is allowed to use the system, he/she should be registered first. A name, user code, and password is entered for each user and saved in this table. In future, different levels of access regarding the system will also be handled here.

Other changes made to the entities mainly involve name changes. These changes generally makes the naming of the tables more applicable to and descriptive of their contents. The following table names were changed:

- Entity HistSys became entity SysHist
- Entity SRExaminations became entity Exams
- Entity SroomExam became entity SideRoom
- Entity SysInq became entity SysExam

A revised list of entities is presented in Table 7.1.

7.3.2 Relationships

The changes regarding relationships, as mentioned in the previous section, are illustrated in Appendix K.

7.3.3 The Entity Relationship (E-R) model

Figure 7.1 contains the updated version of the E-R diagram.

7.3.4 Attributes

In addition to the changes mentioned in section 7.3.1 and 7.3.2, quite a few changes were made to the attributes of certain tables. These changes were necessary in order to comply with requests/improvements as suggested by the evaluators of the first prototype. In order to reduce duplication, only the entities with revised attributes will be presented in tabular

ENTITY	DESCRIPTION
CONSULT	Consultation per patient
DX	Diagnostic measures, e.g. E.C.G. investigation
EXAMS	Lookup table for possible sideroom investigations
FAMILIES	Family demographic information
GAPPEAR	General appearance information per patient per consultation
GATSKE	Six measures for general appearance
GENERALA	Additional notes on general appearance information per patient
LANGUAGE	Lookup table for possible different languages
MARITAL	Lookup table for possible marital status
MEDFUNDS	Lookup table for possible medical funds (aids)
MODIFY	Modifications to existing consultations
NATURE	Lookup table for the different natures of a consultation, e.g. consultation, housecall, operation
PALLERGY	Allergies listed per patient
PATIENTS	Patient demographic information
PCX	Patient counselling/information and follow-up consultations
PDX	Patient diagnostic measures e.g. E.C.G. investigation
PREVEXAM	Previous investigations per patient
PREVILL	Previous illnesses per patient
PREVINJU	Previous injuries per patient
PREVMEDI	Previous medications prescribed per patient
PREVOPS	Previous operations per patient
PROBLEMS	Problems for the problem list per patient
PRX	Therapeutic measures, e.g. prescription, operation
RELATE	Lookup table for possible relationships among patients
SIDEROOM	Sideroom investigations per patient per consultation
SYSEXAM	Systemic examination per patient per consultation
SYSHIST	Systemic history information per patient
SYSTEMS	Lookup table for possible systems in the human body
TITLES	Lookup table for possible titles of patients
USERS	Access control information

Table 7.1 Entities identified for the second EPR prototype

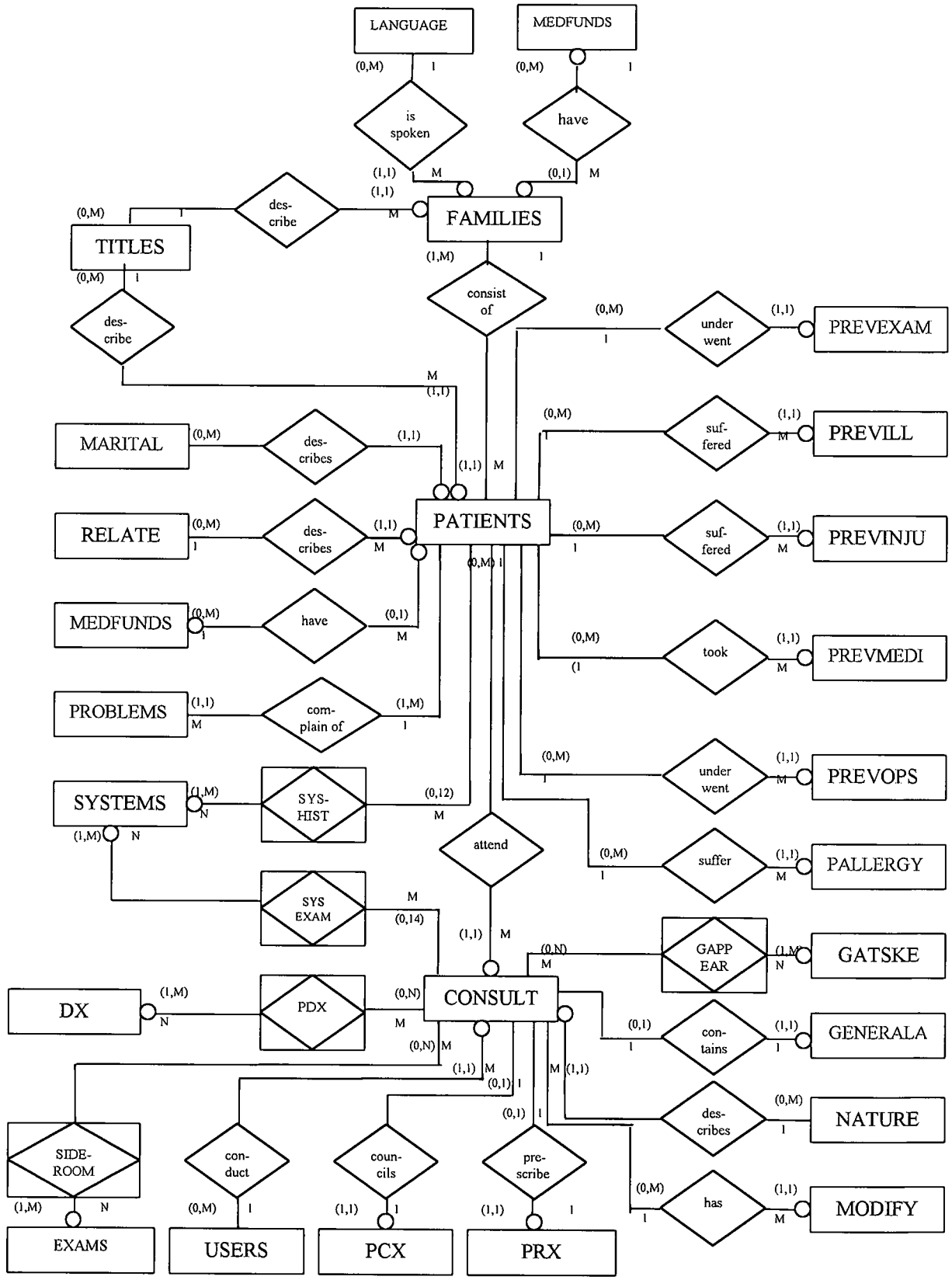


Figure 7.1 E-R Diagram of the Second Prototype

format, in Appendix L. A brief explanation of the changes will also be given in each case. The reader is referred to section 5.3.5 for the unchanged attributes.

7.4 User interface issues

As was the case in section 5.4, the user interface issues that will be addressed in this section are the type of user interface, components used, the colour scheme, and user assistance.

7.4.1 The type of user interface

The type of user interface designed for the second prototype did not alter in principle from the one in the first prototype. The evaluators of the system indicated that they were satisfied with the interface as it was, referring to the graphical-based interface where the mouse and keyboard are both used.

7.4.2 Components used

A major change occurred when comparing the components used in the first and second prototype. The evaluators of the first prototype indicated that they would prefer fewer screens to switch to. This would facilitate and simplify the navigation through the system. They were adamant not to be forced to follow predefined paths when entering information.

In order to comply with these requests, the user interface of the second prototype was based on the Tabsheet component. The Tabsheet closely resembles a paper file with tabs on the side to facilitate filing and retrieving of information. It provided a great metaphor[11] in assisting physicians to feel comfortable and familiar with the computer surroundings. Metaphors are used quite successfully to teach new concepts in terms of ones that are

[11] Knowledge about a familiar domain in terms of elements and their relation to each other is mapped on to elements and their relations in the unfamiliar domain. This is called a metaphor [Preece 1994].

already understood. People can quickly identify with the real-world phenomenon (in this case a paper file) and that instant familiarity gives them a understanding of the computer system [Dix 1998].

The Tabsheets made it possible for the user to see and understand the scope of the system at first glance. "Paths" to all the options (screens) are visible at the top of the screen. The user can also decide which route to take – there is no predefined sequence of actions – and is free to navigate through the system, as he/she prefers. For the purpose of this thesis, the terms *Tabsheet* and *screen* will be viewed as synonyms.

The other components used are similar to those used in the first prototype. An attempt was, however, made to provide the user with more choices to choose from in the form of combo box components. This was done to comply with the request for less typing.

7.4.3 The colour scheme

The decision to use the Tabsheet component had a bearing on the choice of the colour scheme of the user interface. In order to maintain the appealing screen colours (as approved by the evaluators of the first prototype), the same basic colours were used. The application of the colours, however, changed. This was necessary to avoid screens that appeared too "busy".

Instead of using "Teal" as the main colour, the even softer "Silver" was used. "Teal" was used for grids and for headings to distinguish different groups of information. Red was still used where the user's attention needed to be attracted, for example to indicate the patient's allergies.

7.4.4 User assistance

Being a prototype system, it was again decided not to include special help-files, as was the case with the first prototype. The positive feedback from the evaluators of the first

prototype regarding the clarity and ease of use of the system, also gave rise to the decision to stick to the existing type of user assistance, being the status bar, bubble-help, descriptive labels, and meaningful screen layouts.

Additional assistance was provided in order to simplify the typing and entry of data. Examples are the automatic display of the birth date and age of the patient as soon as the identification number is entered, and the automatic display of the initials as soon as the first names are entered. In some places buttons are provided to allow the user to click on them when information from another part of the screen / a previous screen is to be repeated. An example is the transfer of the residential address where the postal and residential addresses of a family do not differ from each other. Where the date of the follow-up visit is to be entered, for example, a calendar is provided to allow the user to select a date by clicking on it, in contrast to typing the date.

With the explanation of the user interface concepts applicable to the second prototype concluded, the next section will give a detailed description and screen examples of the second prototype.

7.5 Description of second prototype

The description of the second prototype will, as was the case in section 5.5, be arranged according to the different tabsheets and screens presented to the user.

7.5.1 Logon screen

The Logon (Fig. 7.2) screen has been refined since the first prototype. Provision has been made to accommodate more than one physician/user per practice, as requested by the evaluators of the first prototype. The user, therefore, chooses the appropriate physician from the list provided, and types in the password, which will appear as asterisks ("*") on the screen. This is a common practice to prevent an onlooker from identifying your

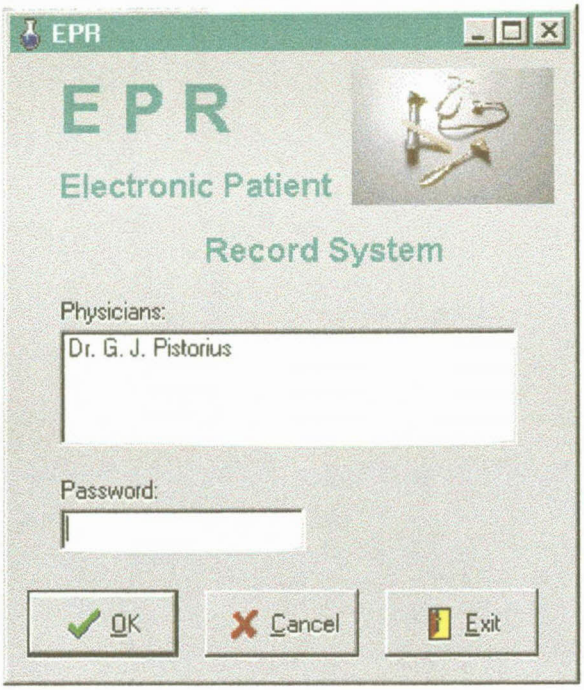


Fig. 7.2 Logon screen

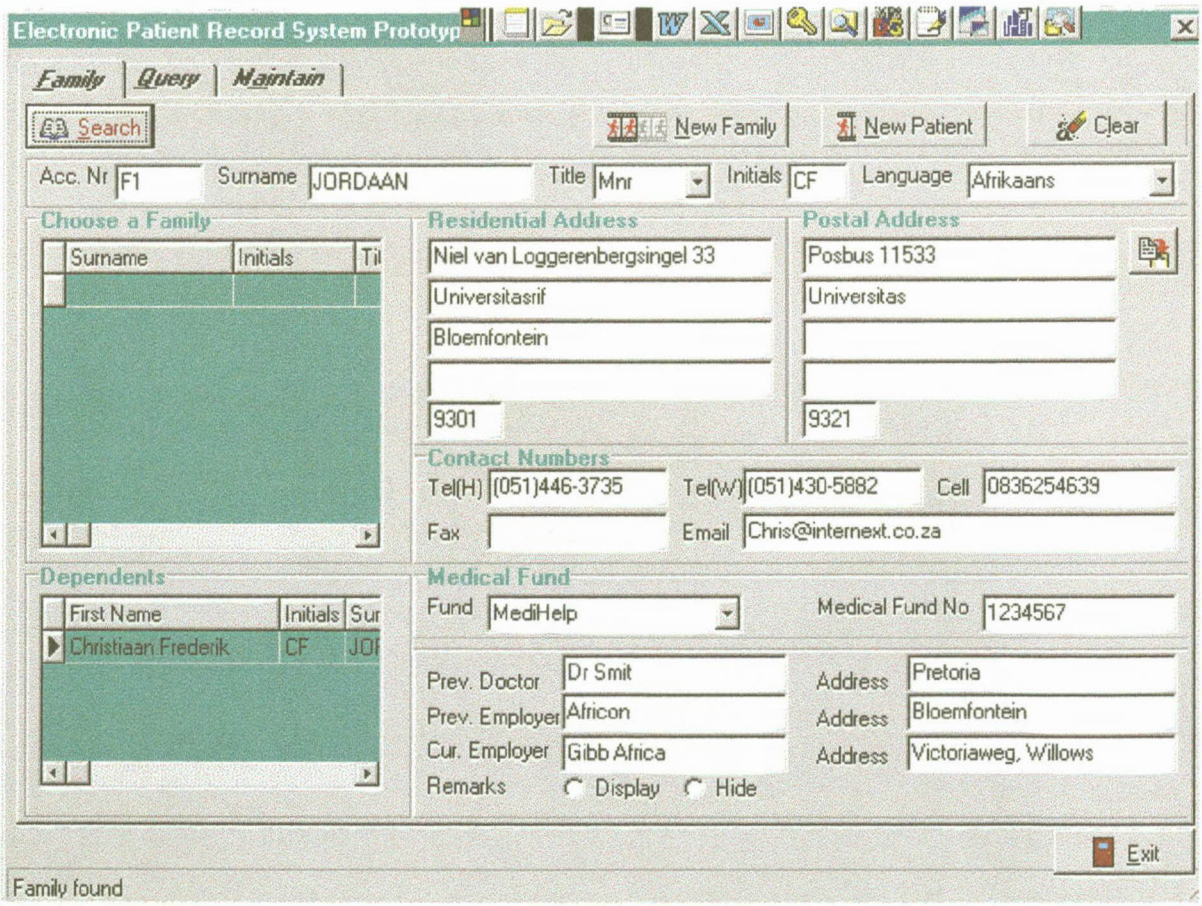


Fig. 7.3 Family screen

password while it is typed. If the password is incorrect, an appropriate message will appear and access will be denied. The user is presented with an OK, Cancel, and Exit button at the bottom of the screen. The Cancel-button will cancel the entered password and clear the input fields, the Exit-button will close the application and the OK-button is pressed after the appropriate physician has been selected and the password entered. The Family screen will then appear on the screen, if access has been granted.

7.5.2 Family screen

The basic layout and functioning of the Family (Fig. 7.3) screen did not change dramatically from the first prototype. At first glance, the reader will notice that fewer buttons appear on the screen. This is a direct result of the use of the Tabsheet component. The user is presented with the available tabs at the top of the screen that can be clicked to move to the selected screen, hence the redundancy of previously used buttons.

This might be a good place to also mention the provision of the Exit-button. The Exit-button appears on the bottom right-hand corner of the screen ... meaning *every* screen.

The Tabsheets make it possible to have the bottom part of the screen visible throughout the whole application. This implies the use of only one Exit-button and the provision of an Exit path from anywhere in the system. When the Exit-button is pressed, a warning message appears informing the user that pressing the OK-button on the message box will totally close the application. If the Exit-button was therefore accidentally pressed, the user has a chance to rectify the situation.

Returning to the above-mentioned tabs, when entering the Family screen for the first time, only three tabs appear at the top of the screen, namely Family (the current tabsheet), Query, and Maintain. Although the second prototype was designed in such a way to guarantee freedom of movement among screens, this is the only exception. As is the case in practice, each patient must belong to a family. Therefore, in order to retrieve a specific patient, it is crucial to first retrieve the information on the family. The hidden tabs (e.g.

Patient, History, etc.) are meant to remind the user to first retrieve a family before a patient record can be selected. The Query and Maintain tabs will be discussed in sections 7.5.13 and 7.5.14 respectively.

New features on the Family screen include the following:

- Fields for entering the residential address have been added (as per request by the evaluators).
- A button appears next to the fields for entering the postal address. In the case where the residential and postal addresses are identical, the user can simply click the button. The residential address will then be copied to the postal address.
- Provision has been made for an e-mail address.
- The entering of remarks concerning the family has been approached differently in the second prototype. The evaluators of the first prototype indicated that it is sometimes necessary to enter remarks which are meant for "the physician's eyes only"! To accommodate this request, a memo field where remarks can be entered, is initially hidden from the user. Two radio buttons are provided. When clicking on the "Display"-button, the memo field will appear and the physician can commence with entering the remarks. When done, clicking on the "Hide"-button will hide the remarks again.
- At this stage it is important to note that, on the Family and Patient tabsheets, no OK-button for saving information has been provided. This was done to accommodate the fast movement between these two tabsheets. Saving is done automatically every time the user leaves a particular screen.

From the Family screen the user gains access to the Patient screen in the same way as discussed in section 5.5.2.

7.5.3 Patient screen

As soon as the Patient screen (Fig. 7.4) is displayed, the user will notice that a whole list of tabs appears at the top of the screen. The user now has access to all the capabilities of the system.

Although the information captured and displayed on the Patient screen do not differ substantially from that on the first prototype, the layout of the screen was changed. This was done to accommodate the few new fields and to arrange the screen in a more meaningful and aesthetic manner.

The additional changes to the Patient screen involve the following:

- As was mentioned in the previous section, the use of tabsheets made many of the previously used buttons redundant. The only buttons presented to the user on this screen are the New Patient and Cancel buttons, the functions of which did not change from the first prototype.
- A field for displaying the patient's age was added. The evaluators requested this feature. As mentioned before, as soon as the identification number is entered, the date of birth and age are automatically calculated and displayed.
- The evaluators of the first prototype noted that the date format was not used consistently. To rectify this problem, it was decided to use the yyyy/mm/dd date format throughout the system.
- The family residential address fields are automatically copied from the Family to the Patient screens. On the Patient screen these fields are disabled (the user is not allowed to change them). For cases where these addresses do, however, differ from each other, the user is presented with a button next to the residential address. By pressing the button, the fields are enabled and the necessary changes may be made.

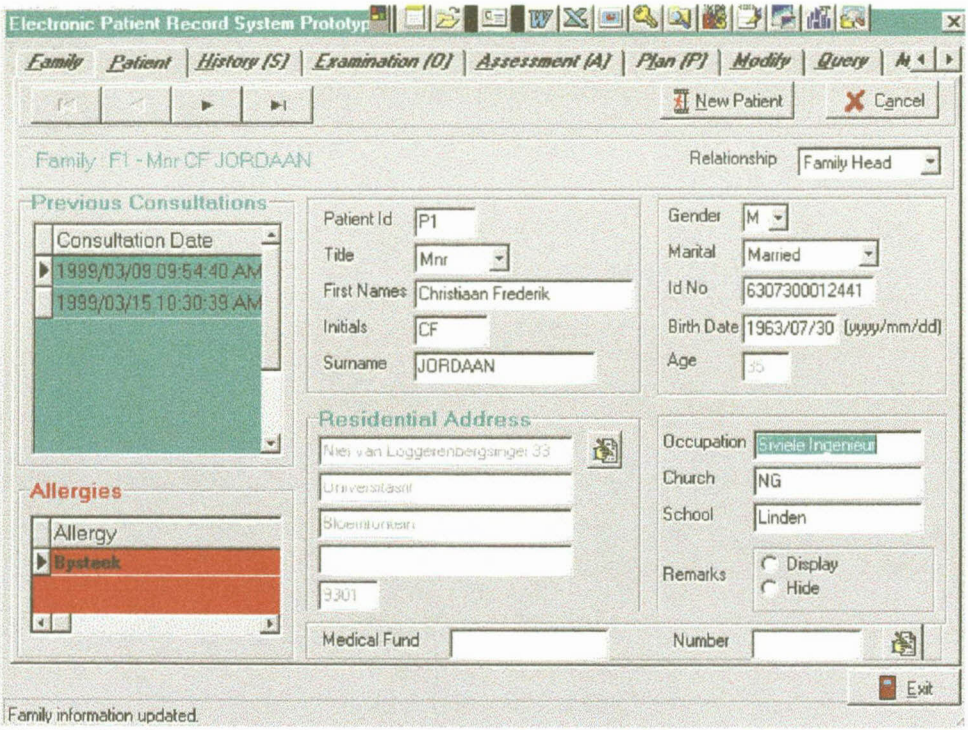


Fig. 7.4 Patient screen

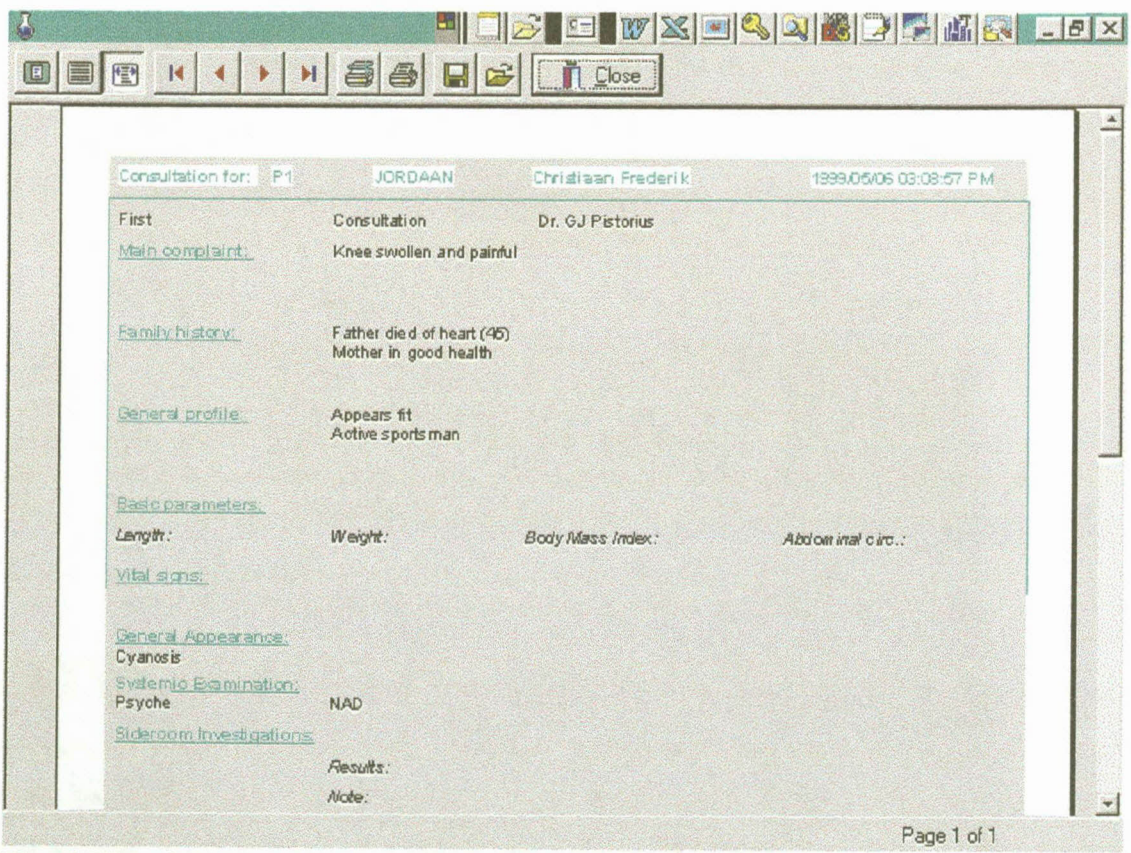


Fig. 7.5 Previous consultation screen

- As a result of the evaluation results of the first prototype, it was noted that some medical aids allocate a medical aid number per individual patient, and not per family, as was the norm previously. To accommodate these cases, fields for the medical fund and medical fund number were created on the Patient screen. The Family medical fund information is regarded as being the default. If the patient's information differs, it needs to be changed on the Patient screen.

After the patient record is created/updated, the user has the option to either start creating the medical note for the current consultation, or to view a previous consultation. The following section will explain how a previous consultation can be viewed.

7.5.4 Previous consultation screen

In the first prototype three different screens were used to display a previous consultation. In order to comply with requests arising from the evaluation of the first prototype, the second prototype was adjusted in order to combine and display all the information pertaining to a previous consultation on one screen.

A previous consultation is shown to the user in the format of a preview of a printed document. As was the case with the first prototype, access to this information can be gained by double-clicking on a date of a previous consultation as displayed in the appropriate grid on the Patient screen. The preview as seen by the user, as well as the identical associated paper printout, complies with the principle called WYSIWYG (**W**hat **Y**ou **S**ee **I**s **W**hat **Y**ou **G**et). From a user interface perspective, especially when taking a human user into account, it is a principle to strive towards [Shneiderman 1998].

Fig. 7.5 gives an example of what a previous consultation could look like on the screen.

In the following few sections, the details of how to capture the consultation, will be explained.

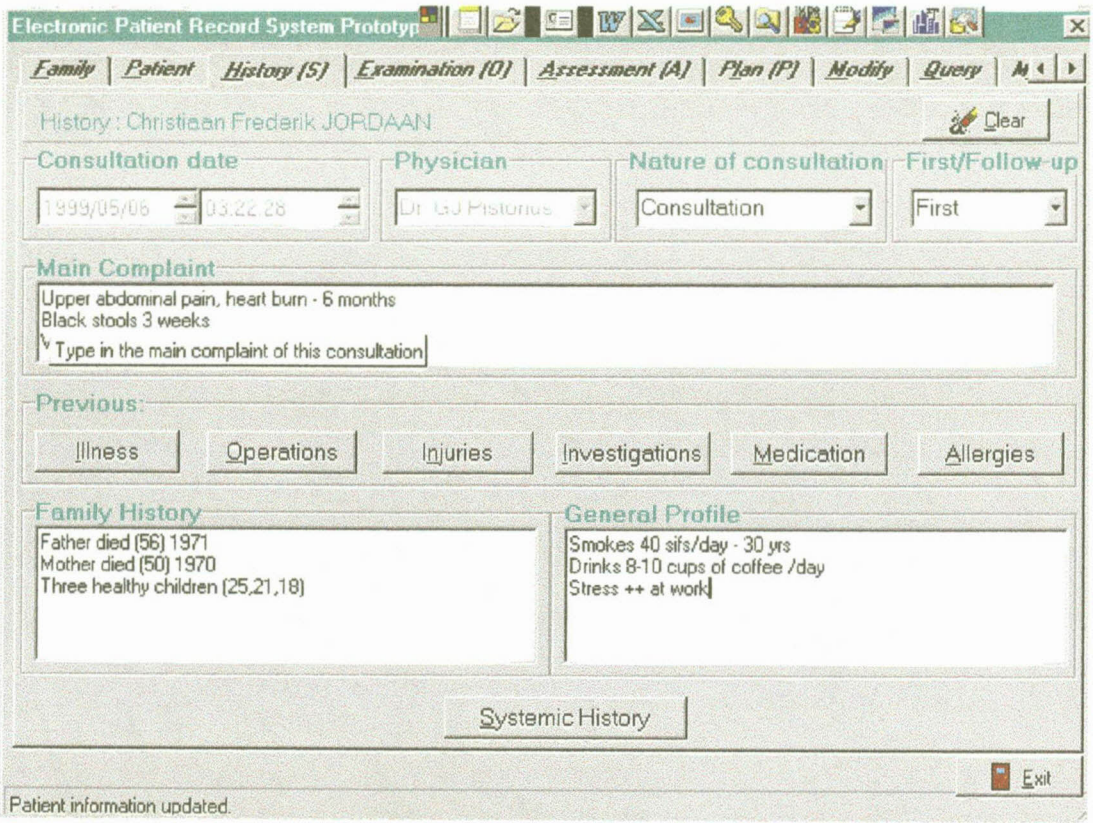


Fig. 7.6 History screen

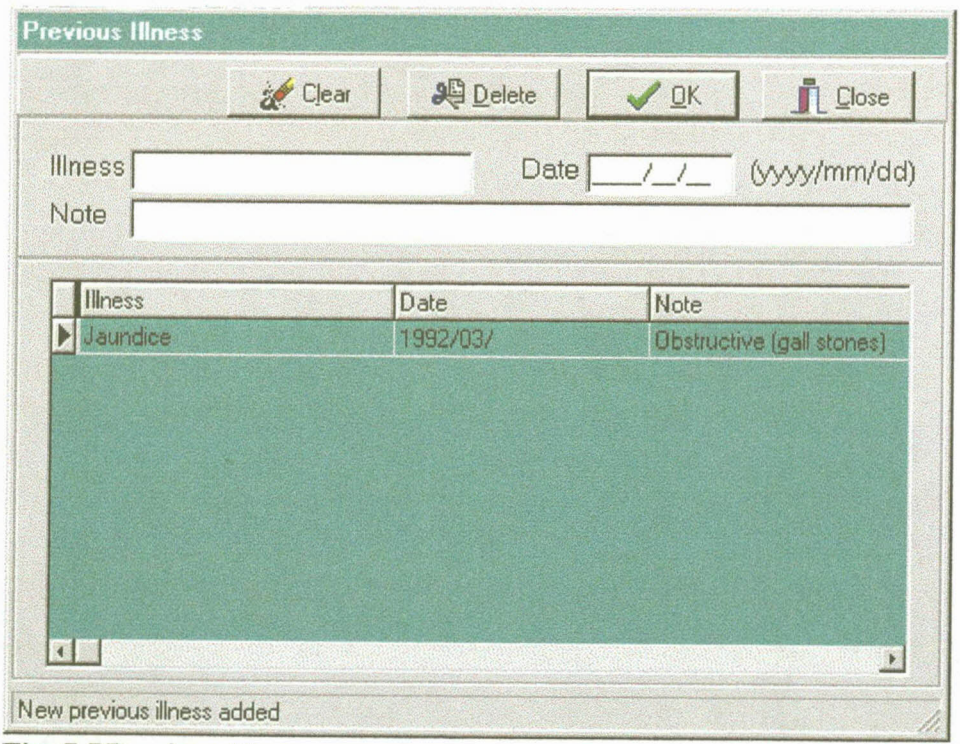


Fig. 7.7 Previous illness screen

7.5.5 History screen

In the first prototype the current date and time were only *displayed* to the user and served as the consultation date. As was pointed out during the evaluation process, the physician needs to be able to alter the date in certain cases. One example is when clinical information regarding a house call (made the previous evening) needs to be captured. The new prototype was therefore designed to allow the physician to alter the date and time of the consultation. To comply with medico-legal requirements, the actual consultation record entry date and time is written to the database in the background. Two dates therefore exist, one to indicate when the consultation took place, and one to show when the information was captured into the system.

The name of the attending physician (the physician who logged onto the system) is also displayed on the History screen. Two fields that appeared on the Examination screen in the first prototype, were moved to the History screen in the second prototype. They are the "Nature of Consultation" and "First/Follow-up" fields. Because the information for these fields is available from the start of the consultation, it seemed more logical to position them on the History screen. During the evaluation the request was also made to have "Consultation" and "First" as the default values for these two fields respectively.

The most important difference between the History screens of the first and second prototypes can be found in the Family History and General Profile fields. In the first prototype this information was stored only once and could therefore not be adjusted. This, however, is not in accordance with the practical situation, as was pointed out in the evaluation results. Thus, in this new prototype, the Family History and General Profile fields were linked to an individual consultation (Fig. 7.6).

As was the case with the History screen, as discussed in section 5.5.6, buttons on the screen give access to screens where the user can manipulate information regarding previous illnesses (Fig. 7.7), previous operations, previous injuries, previous investigations, previous medications, and allergies. Most of these screens stayed the same

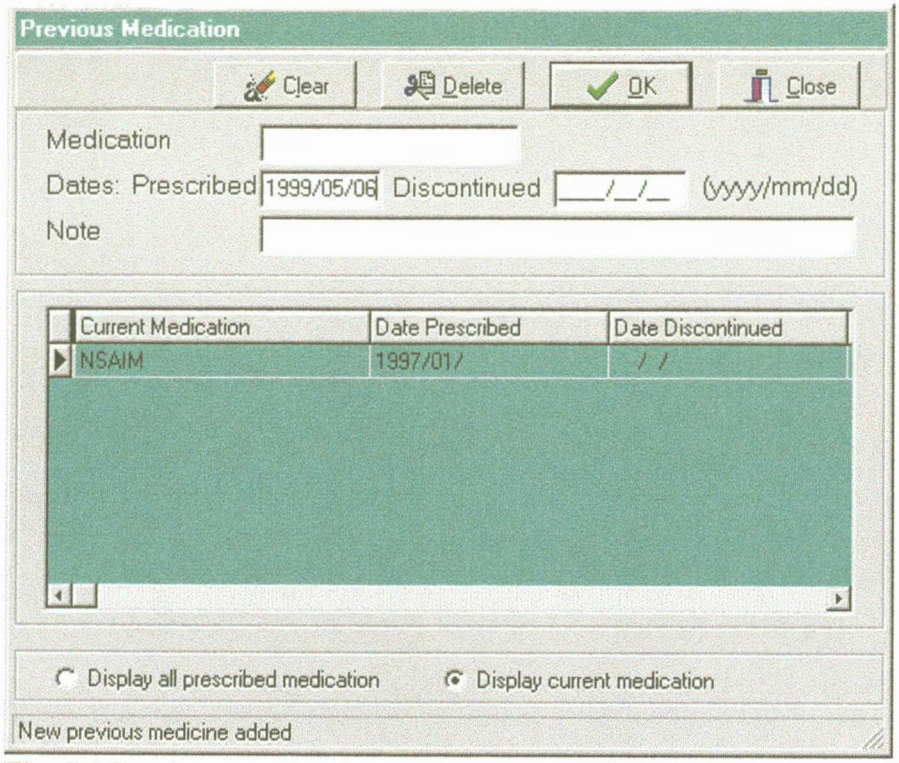


Fig. 7.8 Previous medication

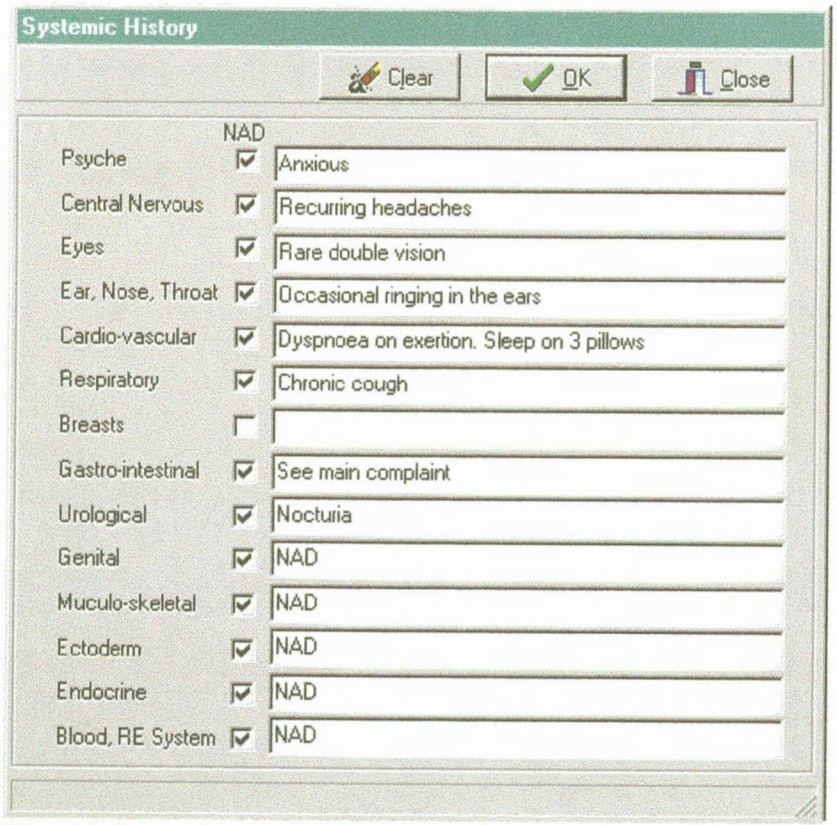


Fig. 7.9 Systemic history screen

as in the first version, except the Previous Medication screen (Fig. 7.8). Here the date associated with the medicine was replaced by two dates, namely the date on which the medicine was prescribed and the date when the medicine use was discontinued. At the bottom of the screen two radio buttons were also added. The default option is to display all the current medication, while the other button provides the option to display all the medication, whether it's use has been discontinued or not.

As was the case with the previous prototype, another button on the History screen gives access to the Systemic history screen. This screen will be discussed in the next section.

7.5.6 Systemic history screen

Two changes were brought about on the Systemic history screen (Fig. 7.9). The first change involves the systems that are displayed on the left-hand side of the screen. In the first prototype thirteen systems were listed. As a result of the first prototype evaluation, fourteen systems are now listed. The Uro-genital system is divided into the Urological and the Genital systems.

The other change involves the functioning of the check boxes that are provided next to each system. While their purpose in the first prototype was only to indicate that information on the specific system has been entered, the second prototype provides them with a much more meaningful purpose. When clicking on the check box, the term NAD (Nothing Abnormal Detected) will appear next to the system. The user is free to change his/her mind by clicking on the check box again (which will clear the NAD from the information field) and enter appropriate remarks in the information field. The reason for providing the NAD option is founded in the medico-legal area. This will help protect the user from negligence charges if he/she can indicate that a specific system was looked at, but that nothing abnormal was discovered. If no comments were entered next to the system (the way in which the first prototype functioned), it would be very difficult to prove that a specific system was indeed examined.

The rest of the Systemic history screen functions in the same manner as the one in the first prototype.

As was mentioned earlier, the History screen represents the "Subjective" part of the SOAP model. The Examinations screen, which will now follow, represents the "objective" part of SOAP.

7.5.7 Examination screen

With the "Nature of Consultation" and "First/Follow-up" fields moved to the History screen, the main section of the Examination screen (Fig. 7.10) contains the patient's basic parameters (height, weight, body mass index, and abdominal circumference) and vital signs (temperature, pulse, respiratory rate, and blood pressure). An additional feature that was provided is the display of measures next to the body mass index and abdominal circumference fields. For different categories of body mass index and abdominal circumference values, different "states" will be displayed. Examples are the display of "Overweight" or "Obesity" next to the body mass index field of an overweight person.

Where a button gave access to the General appearance screen in the first prototype, this information appears on the Examination screen in this version. A memo field provides adequate room for entering general information regarding the General appearance of the patient. If a patient suffers from one of the conditions listed for General appearance, the check box next to the condition should be clicked. Additional information can be entered in the provided field next to the check box.

The Systemic examination and Sideroom Investigation buttons gives access to these two screens, which will now be discussed in turn.

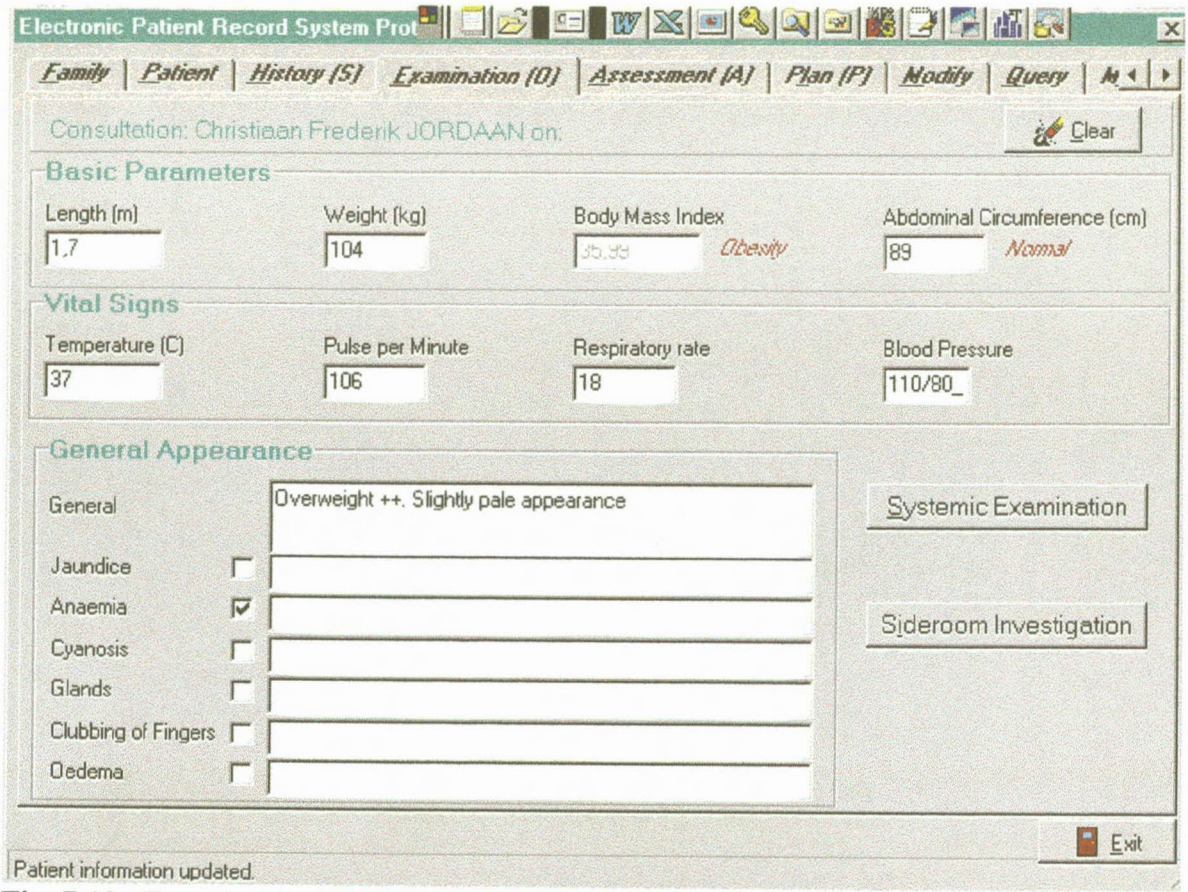


Fig. 7.10 Examination screen

7.5.8 Systemic examination screen

The Systemic examination screen is identical to the Systemic history screen (refer to section 7.5.6), except that the information here relates to the current systemic condition of the patient for the specific consultation.

7.5.9 Sideroom investigation screen

The most obvious change on this screen (Fig. 7.11) in comparison to the first prototype is the title of the screen. The term "Investigation" is now used instead of "Examination". This was a change recommended by the evaluators of the first prototype to be more precise and to avoid confusion.

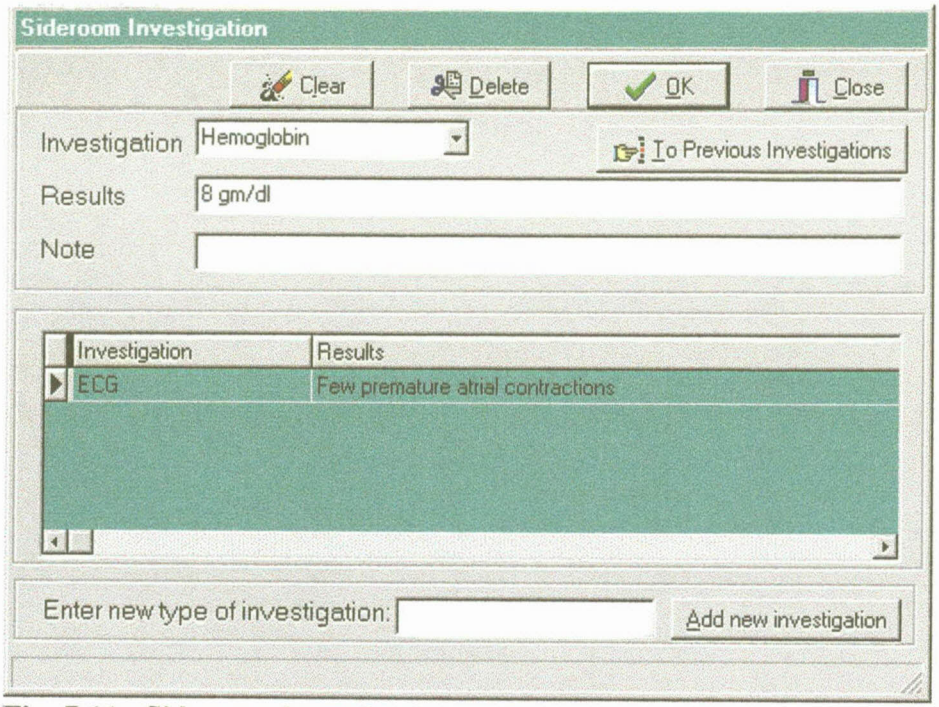


Fig. 7.11 Sideroom investigation screen

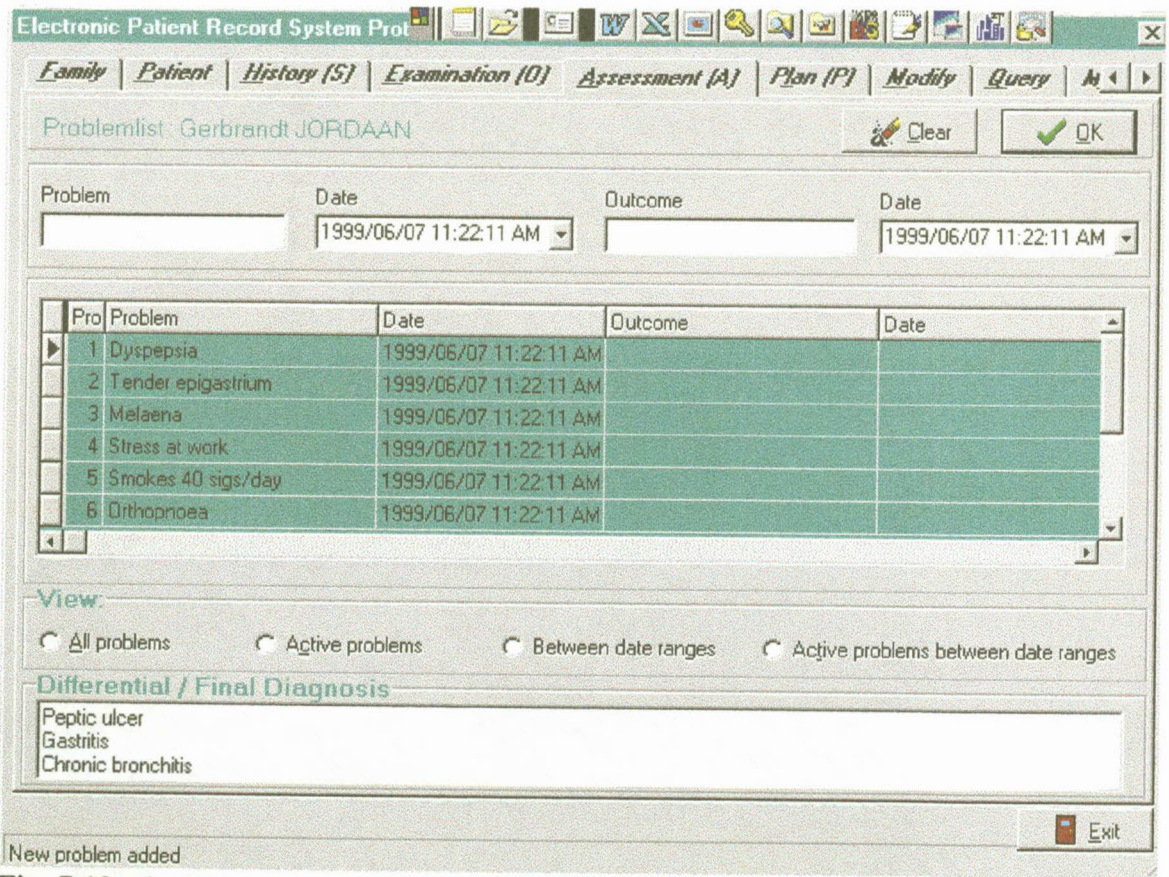


Fig. 7.12 Assessment screen

In order to be more consistent throughout the system, the extra grid that was used for adding new investigation possibilities was replaced. A dropdown combo box now displays the possible choices of investigations. At the bottom of the screen an edit box is provided for entering any new investigations which do not appear in the available choices. By clicking on the "Add new investigation" button, the new investigation will be added to the list displayed by the dropdown combo box.

Another important aspect is the button "To Previous Investigations". As soon as an investigation is added for the specific patient, it is automatically added to the investigation history record of the patient. By pressing this button, the user will be returned to the Previous Investigations screen where he/she, at one glance, can see which investigations the patient has already undergone. By closing the Previous Investigations screen, the user will be returned to the Sideroom investigation screen.

With the Examination screen information in place, the Assessment screen, which represents the "A" in SOAP, will be discussed next.

7.5.10 Assessment screen

The Assessment screen, or Problem list as it is generally known, is shown in Fig. 7.12. The functioning of this screen did not change in comparison to the first prototype. The four viewing options at the bottom of the screen, namely to view all problems, all active problems, all problems between certain date ranges and to view all active problems between certain date ranges, still apply. Fig. 7.13 shows the screen where the user can determine the date ranges, as mentioned above.

An additional field, namely the Differential/Final Diagnosis, was added to the Assessment screen. This field was previously placed on the Examination screen, but according to the evaluators of the first prototype, the Assessment screen is the more logical place for entering the diagnosis.

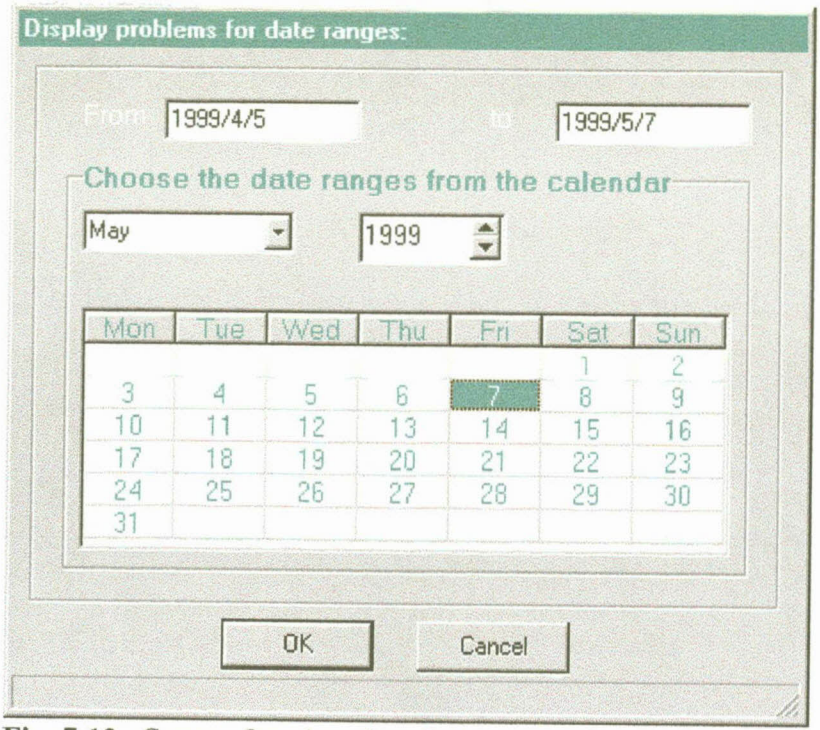


Fig. 7.13 Screen for choosing date ranges for displaying the problem list

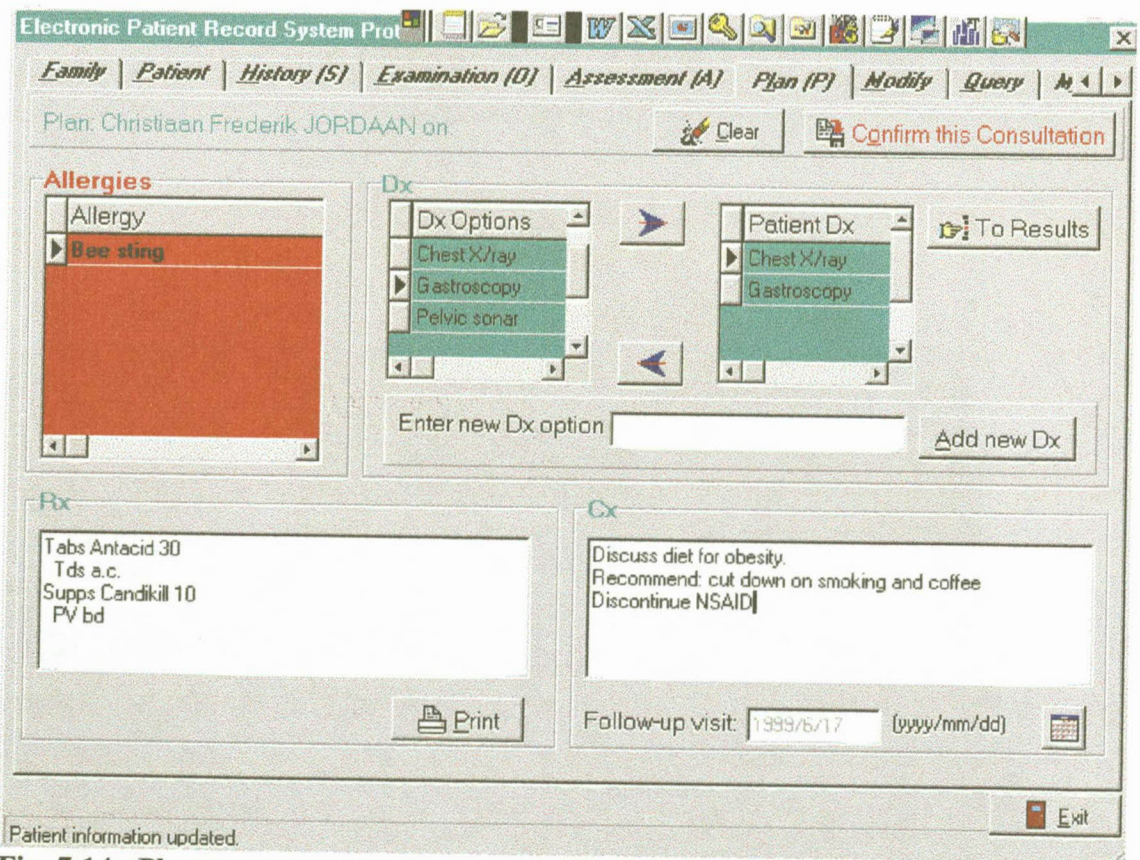


Fig. 7.14 Plan screen

The Plan screen, representing the "P" in SOAP, will be addressed in the following section.

7.5.11 Plan screen

The main information on the Plan screen (Fig. 7.14) still remains the diagnostic measures (Dx), the therapeutic measures (Rx), and the counselling information (Cx). Additionally, as this type of information is strongly linked to a patient's allergies, the evaluators requested that the list of allergies (also in red) should be duplicated here.

Another feature that was added, is the provision for entering a follow-up visit date in the Cx-section. This can be done by either typing in the date, or by clicking on the provided calendar button next to the date edit box at the bottom right of the screen. Fig. 7.15 shows the calendar from which the user can choose the follow-up visit date. After pressing OK on this Calendar screen, the date as chosen will be displayed in the Follow-up visit edit box on the Plan screen.

At this stage of entering the consultation, the user is free to move to any of the SOAP screens and make changes/additions where required. When satisfied that the consultation is properly entered, the user may click on the "Confirm this Consultation" button. The user is asked to confirm his/her intention of saving the consultation. This is done, as the information for this specific consultation cannot be reached to make changes after it has been saved. This prevention of the tampering with medical notes after the consultation has been concluded also complies with medico-legal requirements.

There are, however, cases where a physician needs to add/change information pertaining to a consultation. He/she might, for example have neglected to type in certain remarks made by the patient. The second prototype provides for these changes by supplying the user with a separate screen, namely the Modify screen. The next section will explain how modifications may be made.

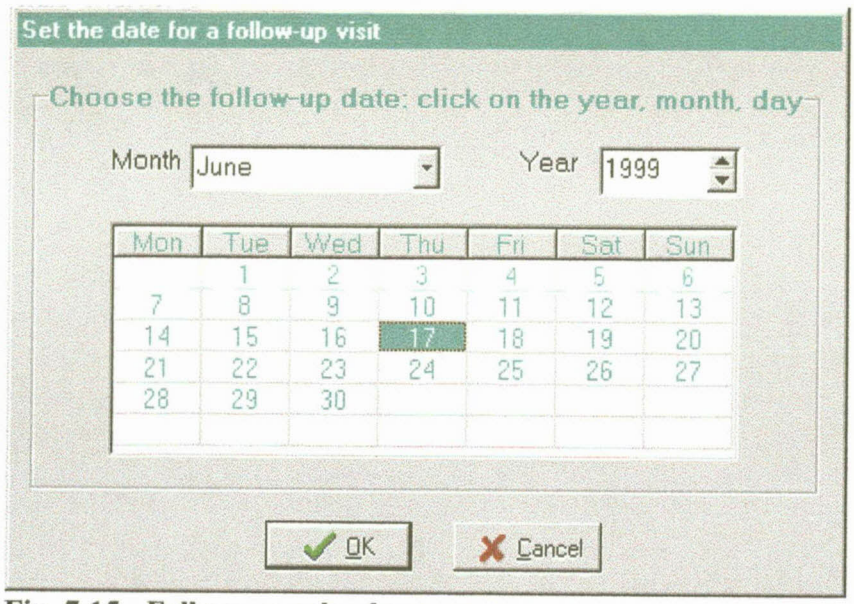


Fig. 7.15 Follow-up calendar screen

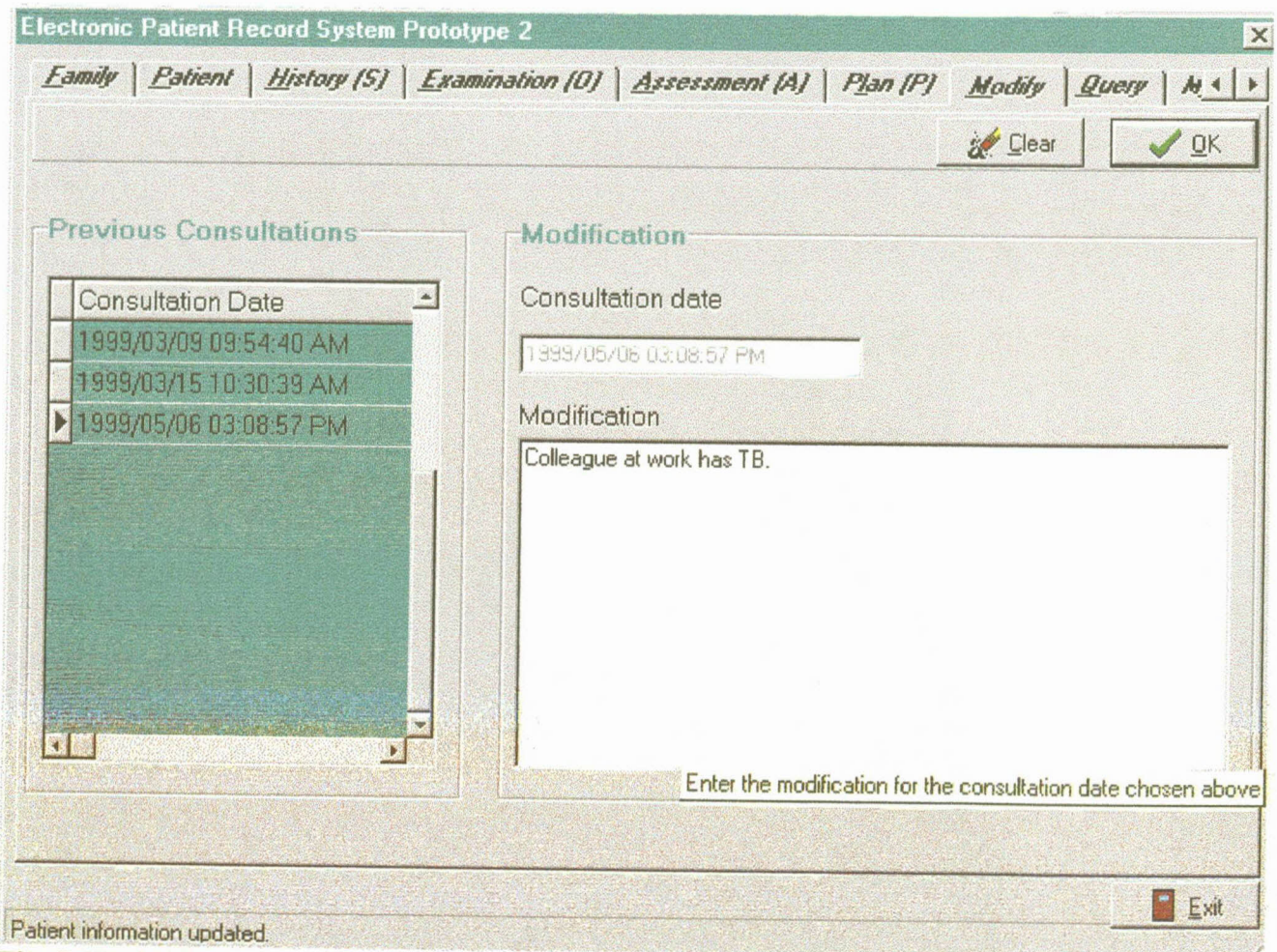


Fig. 7.16 Modify screen

7.5.12 Modify screen

The Modify screen (Fig. 7.16) is an added feature when compared to the first prototype. It takes the format of a type of "minutes" added to a specific consultation. When the user needs to add information to the already-saved consultation, the Modify screen can be used.

On the Modify screen, the user is presented with a grid listing the dates and times of the specific patient's previous consultations. He/she then has to select a consultation by double-clicking on the specific date. The consultation date is copied to a consultation date edit box that is disabled (the user is not permitted to change or type information in this box). The addition/change that the physician needs to make, can then be typed in the provided memo field below the consultation date. The OK-button saves the modification. In the background the date and time on which the alteration is made, will be written to the database for medico-legal purposes.

7.5.13 Query screen

The Query screen (Fig. 7.17) is another new feature to the second prototype. The need for a query feature was indicated in the evaluation results of the first prototype (refer to section 6.4). It often happens in practice that a patient phones with a query while the physician is busy with the consultation of another patient. In order to comply with the request of handling such a situation, the Query screen was created. While busy entering information pertaining to a specific patient, the physician can move to the Query screen and make enquiries on any other patient. When satisfied with the results of his query, he/she can go back exactly to where he/she was before the interruption and carry on with the consultation as if nothing has happened.

How is this accomplished? On the Query screen the user is presented with an information box where a family can be searched via account number or surname (part thereof), just as

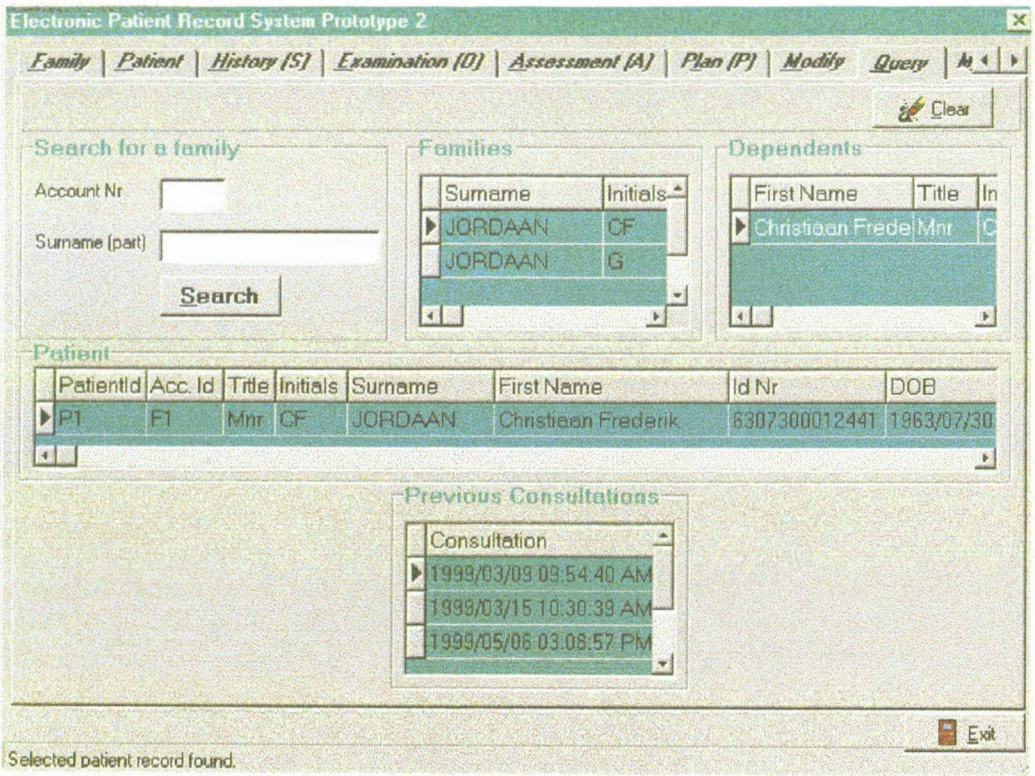


Fig. 7.17 Query screen

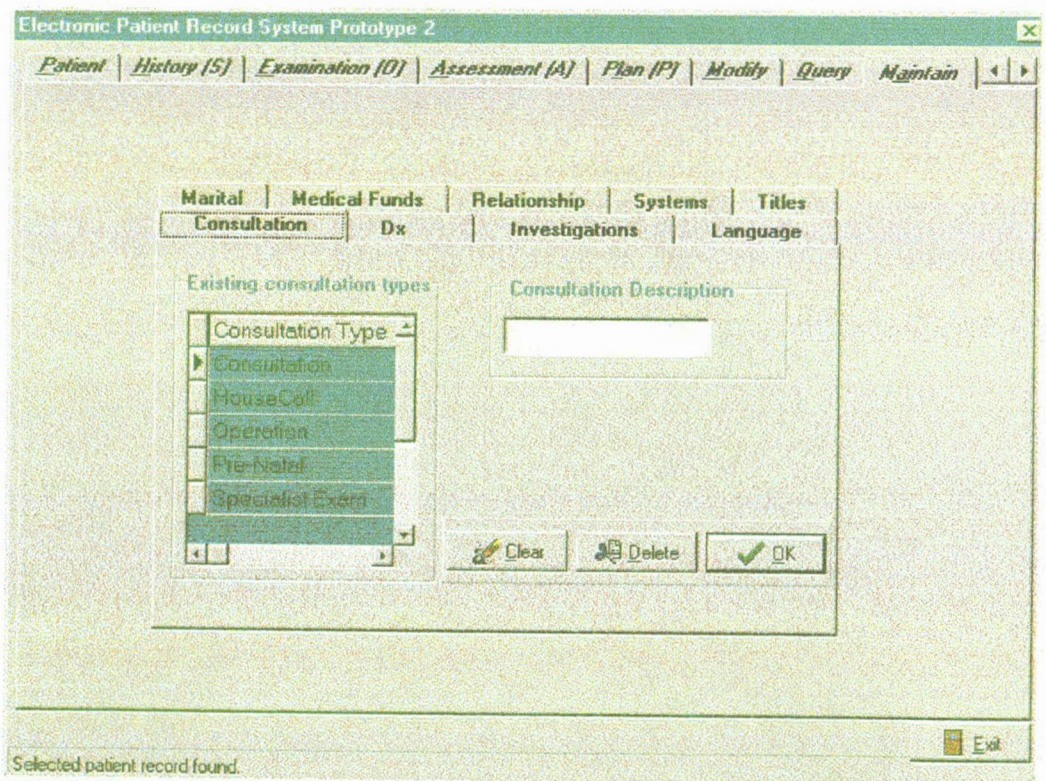


Fig. 7.18 Maintain screen

a family is searched for on the Family screen. If an account number is entered, two grids appear simultaneously – one containing the family information and the other one listing all the dependants of that family. When searching on the family surname, a grid will be displayed listing all the families complying with the search condition. By double-clicking on the selected family in the grid, the list of dependants of that family will appear.

By selecting the appropriate dependant (patient), a grid with all the patient's particulars will appear on the screen, as well as a grid listing the dates and times of the patient's previous consultations. In the same manner as was applied on the Patient screen, the physician will be able to look at the details of a previous consultation.

When the query has been concluded, the physician will be able return to where he/she left off, and continue with the consultation of the patient in front of him.

7.5.14 Maintain screen

The Maintain screen (Fig. 7.18) presents the part in the second prototype where the system can be customised according to the physician's needs and preferences. Many additional features can still be provided here, but for the purpose of the second type, this screen was restricted to the maintenance of "choice lists". To clarify, take the list of titles that is presented to the user in a drop-down combo box on the Family and the Patient screens. If the physician comes across a patient with a title that does not appear on the list presented to him, he would go to the Maintain screen. On this screen he can then select the Titles tabsheet and add/modify/delete titles as needed.

The other information that is maintained on the Maintain screen include the consultation types, Dx options, list of investigations, home languages of patients, marital status, medical funds, different relationships of patients with the family head (e.g. wife, child), and the different bodily systems as listed in the systemic history and systemic examinations. All these screens function in the same way. When a modification needs to be made, the specific item listed in a grid will be selected. By double-clicking on it, the item will be

moved to the edit box on the right-hand side where the modification can be made. By pressing the OK-button, the modification will be saved and the modified item will appear on the grid. The same method applies when an item needs to be deleted. The only difference is that, when the Delete-button is pressed, the user has to confirm the deletion. When confirmed, the item will be deleted from the database and will also disappear from the list on the screen. A new item that needs to be added may be typed in the provided edit box. When the OK-button is pressed, the item will be added to the database and will appear on the list on the screen.

7.6 Summary

This chapter gave an in-depth look at the second prototype EPR system. The development environment, database design, user interface issues, and different screens were discussed, with specific mention of the differences between the first and second prototypes and the changes made to the second prototype. These changes were brought about as a result of the evaluation of the first prototype by a group of general practitioners.

In Chapter 8 the HUB system will be discussed. This is a demonstration program bought from America. The purpose of including it in this research is to test the physicians' opinions regarding the use of Foresighted Practice Guidelines in comparison to the template method, as was applied in the first and second prototypes. The HUB system is based on Foresighted Practice Guidelines.

Chapter 8

The Third Alternative: HUB system

8.1 Introduction

In order to ensure the correct interpretation of the "big picture" concerning this research, it is deemed necessary at this stage to briefly answer the question: "*What has been achieved so far, and where to from here?*"

The main purpose of this thesis is to determine what an EPR system should look like in order for general practitioners to be willing to use it in their practices. In Chapter 5 a first EPR prototype system that was developed and evaluated, was discussed. The results of the evaluation of this prototype were used to develop a second prototype, as discussed in Chapter 7. These two prototypes were based on the template model (refer to Chapter 2) and were developed "from scratch". In order to give the evaluators a wider perspective on how EPRs might function, a third alternative system was introduced. This alternative is a demonstration version of an American system called the HUB Computer Medical System. It is, therefore, an existing system in contrast to the first two prototypes that were developed for this research purpose. The main reason for selecting HUB as the third alternative is that it is based on the Foresighted Practice Guidelines principle (refer to Chapter 2). By presenting physicians with two alternatives (the second prototype and HUB), from either side of the equator, it is expected to gain valuable information regarding the expected appearance and functioning of a generally acceptable South African EPR system.

In this chapter the HUB system will be discussed. First an overview of the system will be given. In the next section three file structures used by HUB are discussed. Finally a description of the functioning of the HUB system will be given, describing the directories

used, identifying the HUB programs, giving a brief example of a typical HUB consultation, and concluding with a brief "tour" through the system, highlighted with a few print screens. As mentioned in the previous chapter, the evaluation process and results concerning the second prototype and HUB will be discussed simultaneously in Chapter 9.

8.2 An overview of HUB

The overview of the HUB will start with a general discussion/description of the system, followed by explaining the "alliance" between Foresighted Practice Guidelines and HUB. The operating system, hardware requirements, and user interface issues will subsequently be discussed.

8.2.1 General discussion / description of HUB

The HUB system was designed by the American, Doctor Thomas A. Naegele, who is both a board-certified Family Practice physician and a computer systems analyst. It is a clinical medical record software package that takes a chief complaint, finding or medical condition and moves the physician from symptoms to objective findings, to assessment and to treatment plan. As one moves through these groups, the programs allow for choices to be made from each group. Subsequently a medical note is created.

8.2.2 The "alliance" between FPGs and HUB

The HUB system is different from other systems in that it does not use a template. It is designed around the Foresighted Practice Guideline Model, as was discussed in Chapter 2. HUB is, therefore, a practice guideline engine. It allows the user to define the health care encounter in terms of decision table logic. These decision tables are placed in the order in which the steps of the physician-patient encounter actually occur. The resultant physician-patient-computer interaction using this model creates a medical note and permanent record of the event. The user(s) have the opportunity to build their own FPG databases (collection of decision tables), or they can use or modify some that have

already been created. Building guidelines requires the ability to use a computer ASCII editor, a basic idea of a computer filing system and a solid medical knowledge. These FPG databases are the heart of the system – they control the user in all aspects.

HUB also allows for outcomes research, inventory management, risk management, and process flow management. Its inventors claim that HUB is a 21st century approach and the only object oriented health care software system and FPG engine on the market. Although the latter claim might be true, the author is of the opinion that the former claim may be perceived as optimistic. Many of the international originated EPR systems available on the market nowadays may be classified as object-oriented systems, as is indeed propagated in their marketing brochures.

8.2.3 Operating system

As far as the operating system is concerned, the HUB system is supported under MSDOS 3.0 and above. It apparently has been successfully tested under OS2 and PenDOS. The program is supported under Novell networking and has its own internal file server for access of up to around 100 000 patients.

8.2.4 Hardware requirements

HUB runs on the Intel 8086 series machines. An Intel 80286 running at 14 MHZ is recommended as a bottom line for the hardware. The memory requirements are 512 MB RAM, and the system can be run as a standalone with diskettes or hard drive, or as a network with a file server.

8.2.5 User interface issues

HUB has a graphical user interface. When using the system, the keyboard is seldom used (although necessary for some tasks). With MSDOS as operating system, the mouse is used. While using the mouse throughout the HUB system, all selections are made by clicking the left mouse button once. To confirm the selection, the right mouse button is clicked once. With PenDOS, on the other hand, a point and click mouse pen is used to

allow the physician to complete the medical record while conducting the actual examination.

8.3 HUB file structures

The FPG Model operates off three public domain data/file structures, namely:

- The Standard Patient File Format (SPFF)
- The Standard Practice Guidelines Format (SPGF)
- The Medical Optical Reader Form (MORF).

HUB, therefore, uses all three of these file structures. Each of these structures, as applicable to HUB, will now be discussed in turn.

8.3.1 The Standard Patient File Format (SPFF)

Though there are many computer filing formats for patient records in the world, Naegele [1995] believes that the most commonly used one is the Standard Patient File Format (SPFF). It has been stated that many physicians use the paper model of this format in every patient encounter. SPFF is an ASCII file format that allows for existing physician profiling programs to gather all of the information about every physician and every physician-patient encounter so that a comprehensive and reliable profile can be obtained.

There are eight main sequential categories in the SPFF that are always there. These categories are:

- Patient demographics
- Front of the Chart
- Symptom / Subjective information
- Objective information
- Assessment information

- Plan information
- Back of the chart information
- Examiner.

Each of these categories ends with an ASCII underline character in column one. The "Back of the chart information" category may end with an underline character in column one or an End of File mark. The first word in the file will be "Patient". The underline character will end the first main category. The next line will have the word "Front" starting in column one. This category will continue until an underline character in column one is detected, etc. Each main category has no limit as far as number of lines is concerned. The line length, however, is limited to 80 characters.

Under each category, a subcategory name will start in column one, while data for that subcategory will start on the following line with a tab character in column one. Each data set for any given subcategory will always have a tab in column one for each new line. There is no limit as to the number of data lines per subcategory.

HUB has two formats, namely the Flat format and the Deep format. The flat format was designed for floppy diskettes. One patient per floppy is recommended, although HUB will apparently be able to handle up to fifty patients per floppy. There is a file in the main directory on the floppy called PTFILE.HUB that uses tag labels. A blank (null) line separates each patient within this file. The required labels are as follows:

Patient's last name
Patient's first name
Patient's middle name
Patient's birth date
Patient's phone number
Patient's gender.

Patient: De Wet, Lizette Birthdate: 7-2-65 Patient #: 123-4567
Time: 08:36:00 Date: 12-5-99
Sponsor Insured: Self

Front Front Front Front
Selected Guidelines
ABD-PAIN URI

Symptom Symptom Symptom Symptom
CC-AbdomenalPain REQUIRED-
This is a 34 year old female brought to the consultation rooms by her husband.
She is complaining of abdominal pain. She has a fever.
Her last meal was within the last 12-18 hours.
SurgicalPastHistory
Colonoscopy was done around 4 years ago.
MedicalPastHistory
Usual childhood diseases.
Duration
Symptoms started within the last 12 hours.
Where
Occurred at home.
Allergies
Denies any drug allergies.
CC-URI
Sore throat. Runny nose. Pain with swallowing.
Denies coughing. Denies ear pain.

Objective Objective Objective Objective
Vitals
BP:105/70, T:100.1, P:88, R:16.
etc.

Fig. 8.1 Extract from an application of SPFF for floppy diskettes in MSDOS

The root directory filename on the floppy diskette will always be equal to the first eight letters of the patient's last name (or less), and the actual medical note entry is the date and

time that it was created. As an example, an extract from an application of SPFF for floppy diskettes in MSDOS is given in Fig. 8.1. This extract represents a medical record entry for patient Lizette De Wet that was created on 12 May 1999 at 08:36 AM. The file name will be: A:\DEWET\99051208.36.

The Deep format was designed for hard drives. The directory scheme that one has to follow, recommends a directory just for patients, for example C:\PATIENTS. The directory structure entails the main directory (in this case C:\PATIENTS), followed by the first two letters of the patient's last name, the patient's full last name, the patient's first name, and the last two numbers of the birth year. The structure is concluded with the patient's examination files.

For the same patient used in the flat file example above, with a birth date of 7 February 1965, the directory scheme will be as follows:

C:\PATIENTS\DE\DEWET\LIZETTE\65\(examination files)

The PTFILE.HUB with the patient's demographics will be located under the patient's first two letter directory:

C:\PATIENTS\DE\PTFILE.HUB

The tag information in PTFILE.HUB as mentioned above, is used to export demographic data among programs.

8.3.2 The Standard Practice Guidelines Format (SPGF)

Besides the patient data (SPFF), there is the information that is presently within the minds of physicians that is used to create the patient's medical notes. The Foresighted Practice Guideline is the data structure for this information. Presently there is only one formal database structure for information used to create the patient files. It is called the Standard Practice Guideline Format (SPGF) [Naegele 1993]. The SPGF is therefore a

data structure on how to arrange practice guideline data files in order for computerised medical note packages to use them. The SPGF could provide the health care provider with information to interact with the patient and all of the other services and departments for every patient interaction. The SPGF could also give the managed care groups the ability to compete by providing information on quality, cost, supplies, and outcomes as measurable variables [Naegele 1995].

In the HUB the package of guidelines can be stored in a subdirectory called GUIDLINE. Within this directory there are eight other sub-directories, namely:

- GUIDELINE\STD
- GUIDELINE\NURSTD
- GUIDELINE\FRONT
- GUIDELINE\SYMPTOM
- GUIDELINE\OBJECTIV
- GUIDELINE\ASSESSMT
- GUIDELINE\PLAN
- GUIDELINE\BACK.

These directories should look familiar as they correspond to the categories of SPFF as listed in Section 8.3.1.

In the GUIDLINE/STD and GUIDLINE\NURSTD directories, all the available guideline files are listed as ASCII files, for example:

C:\GUIDLINE\STD\ABD_PAIN
C:\GUIDLINE\STD\ALLERGIC
C:\GUIDLINE\STD\HEADACHE.

These guideline files, in turn, also contain lists of ASCII files following the SPGF rules. The most important rule is that the file name must start with the directory names FRONT,

SYMPTOM, OBJECTIV, ASSESSMT, PLAN or BACK. After that the actual name must follow MSDOS file name rules. For example, the above-mentioned file C:\GUIDLINE\STD\HEADACHE, may contain the following:

```
Front\Arrival
Symptom\CC_Headache
Symptom\Duration
.
.
.
Objectiv\Vitals Lab-
Objectiv\Head
.
.
.
Back\Xray_Results
```

In the GUIDLINE\FRONT, GUIDLINE\SYMPTOM, GUIDLINE\OBJECTIV, GUIDLINE\PLAN and GUIDLINE\BACK directories are ASCII files that represent lists of clinical decision data and medical industry data. Although the main categories may be listed in different orders depending on the style of the note, their content is organised according to four distinct data types, or sub styles. These sub styles may be used in the same note within different main categories [Naegele 1995]. The four different data types as used in HUB will now be explained.

- **Data type one** – Any phrase that starts with any character, except !, &, and * will represent a phrase as it is to be placed within the medical record, for example:

  No pain at this time

  Pain at this time.

- **Data type two** – This data type starts with an exclamation (!) in column one and ends with a blank line. The exclamation means that a sentence is to be built from the list following. The structure of this data type is: (!(start of sentence)# (# = number of columns to display in window), for example:

!Previous medical problems include 2
Measles
Mumps
Coxsackie
Diabetes
Thyroiditis
(blank line (null)).

- **Data type three** – This data type starts with an ampersand (&) in column one and ends with a blank line. The ampersand solicits input with a maximum number of characters. The structure is: &(user message) # (#=number of characters for the maximum input), for example:

  &Vitals 8
  BP: (BP = blood pressure)
  R: (R = respiratory rate)
  P: (P = pulse)
  T: (T = temperature)
  (blank line (null)).

- **Data type four** – This data type starts with an * in column one. The information following the * represents user information. This information goes into the medical note just as it is written, until a blank line (null) is encountered.

8.3.3 The Medical Optical Reader Form (MORF)

There is presently a variety of interfacing standards. Two of these standards that are probably most relevant to this thesis are Health Level 7 (HL7) [HL7 1999] and European Committee for Standardization Technical Committee 251 (CEN TC 251) [CENTC251 1999]. It is popular belief that HL7 is way out in front as the market leader. Although originally used for order/entry to laboratory systems, HL7 has evolved to encompass the ability to not only move data, but to use the data once it is moved [HL7 1999]. Another interfacing standard in use is the Medical Optical Reader Form (MORF). MORF is being

used to convert information from medical notes to medical billing, order/entry, lab systems, inventory, and pharmacy systems [Naegele 1995]. The HUB system makes use of this interfacing standard.

MORF is a tag-label data structure that is used throughout the computer industry. It allows the end-user to define and select their own tags and data for use in other programs and in communicating with other computers [Naegele 1995].

As far as the billing function in HUB is concerned, HUB will automatically code the medical note and send the information via the MORF interface to existing billing software. This is done in the following way: with the MORF feature turned on, a program within HUB, namely HP.exe, will create a MORF entry. The MORF entry will be located in an ASCII file with the filename being the date and time on which it was created. For example, for a file that was created at 08:36 AM on the 12th of May 1999, the filename will be C:\HUBPAPER\MORF\99051208.36. MORF uses the twenty-four hour clock. The MORF file uses tag labels, meaning that the same tags described in Section 8.3.1 for patient demographic data, will be used along with a few others. The coded medical note will also be in the MORF file.

8.4 Description of HUB system

As an overview, HUB is said to present the following main features:

- Foresighted Practice Guideline Software engine
- Medical note generator
- Medical forms generator
- Interdepartmental communications
- Medical Logging
- Medical Research: Prospective and Retrospective
- Medical billing interface

- Open architecture
- Inexpensive hardware and maintenance
- Total quality management
- Physician control
- Increased efficiency.

In order to provide a glimpse of the HUB Computer Medical System, different aspects will be addressed in this section. First the main directories necessary for the program to function, as well as a few file procedures to get the program started, will be discussed. Identifying and briefly discussing the computer programs that HUB consists of will follow. The course of a typical consultation where the HUB system is used, will then be discussed. Finally, this section will be concluded with a brief "tour" through the system, with examples of a few screens.

8.4.1 HUB directories and data files

The four directories assumed by the HUB Computer Medical Program, are:

- C:\HUB
- C:\HUBPAPER
- C:\GUIDLINE
- C:\HUBDATA.

If so desired, the directory names may be changed and the programs (see section 8.3.2) and data files may be placed in any directory or set of subdirectories. If so, the MSDOS SET command needs to be used in the MSDOS AUTOEXEC.BAT file so that the correct directories will automatically be set as the computer starts up.

The only data files that need mentioning at this stage are the two required files, namely C:\HUB\CONFIG.HUB and C:\HUBPAPER\CONFIG.HUB. The afore-mentioned is used for configuring the Hub program, while the latter is used for configuring the

HubExec program. These configurations are extremely important, because the appearance and functioning of the whole system are determined in these ASCII files. The lay-out and fonts of reports, for example, are set here before the program is used.

8.4.2 HUB programs

The HUB Computer Medical System consists of six main programs, while a few more were still on the drawing board at the time of writing this thesis. These six programs are:

- **C:\HUB\HUB.exe** – Hub is the program designed for physicians to use for point of care data collection.

- **C:\HUBPAPER\HUBEXEC.exe** – HubExec is the program designed for administration to enter demographic patient data and to have access to patient encounter files for the processing of forms.

- **C:\HUBPAPER\HP.exe** – The program HP is run from within Hub, Hubexec, and HubCheck. The user does not directly use the HP program. HP stands for HubPaper and takes a patient encounter and prints all of the forms.

- **C:\HUBDATA\HUBCHECK.exe** – HubCheck is for networked systems. The HubCheck program will check to see if any patient encounters are available and it will then print the associated notes and forms.

- **C:\HUBPAPER\CONVERT.exe** – Convert is used to take patient data stored on floppy disks and transfers it onto the hard disk into the Deep filing scheme.

- **C:\HUBPAPER\ALPHA.exe** – The Alpha program will take the guidelines within the STD and the NURSTD directories and alphabetize them.

8.4.3 A typical HUB consultation

How would a typical consultation using the HUB system be conducted? The physician would walk into the consulting room and ask the patient how he/she can be helped. This is seen as the first step for putting the patient into the correct clinical decision "ballpark". In the first few questions the physician must determine which path to take (which guideline to choose). The real art is in extracting the most clinically important information in the least amount of time.

Once in the "ballpark", the physician goes through a series of mental decision tables. These tables are lists of answers that are appropriate to the name or concept that the table represents (refer to Section 8.2.2) [Naegele 1996].

After the physician-patient encounter, HUB will produce all of the forms and log all of the necessary information for all processes into ASCII files that can be accessed by any text editor. Thus it has been stated that is has a complete open architecture [Win-Win solution].

The reader will now be given a brief "tour" through the HUB Computer Medical System.

8.4.4 A brief HUB "Tour"

The HUB "tour" will firstly include the selecting of an examiner. From there the procedure to select a specific patient will be discussed, followed by the choice of a foresighted practice guideline(s) for conducting the examination. The manner in which choices are made during the consultation will be briefly covered, concluding with how the consultation should be finalized.

- **Examiner** – As soon as the HUB startup screen appears (Fig. 8.2), the mouse button should be clicked to activate the program. The physician should then select the attending physician from the *Choose Examiner* dialog box (Fig. 8.3).

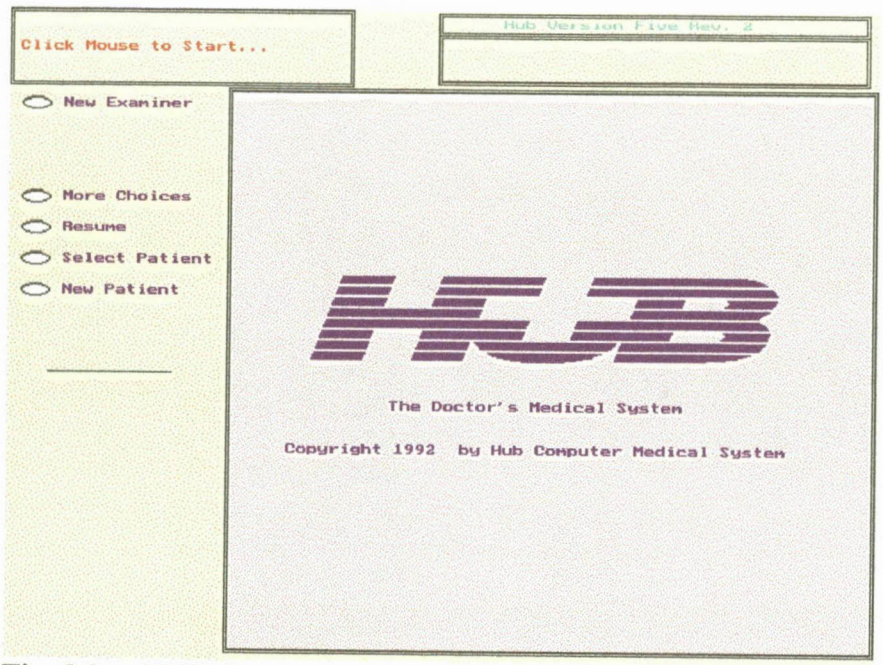


Fig. 8.2 HUB Startup screen

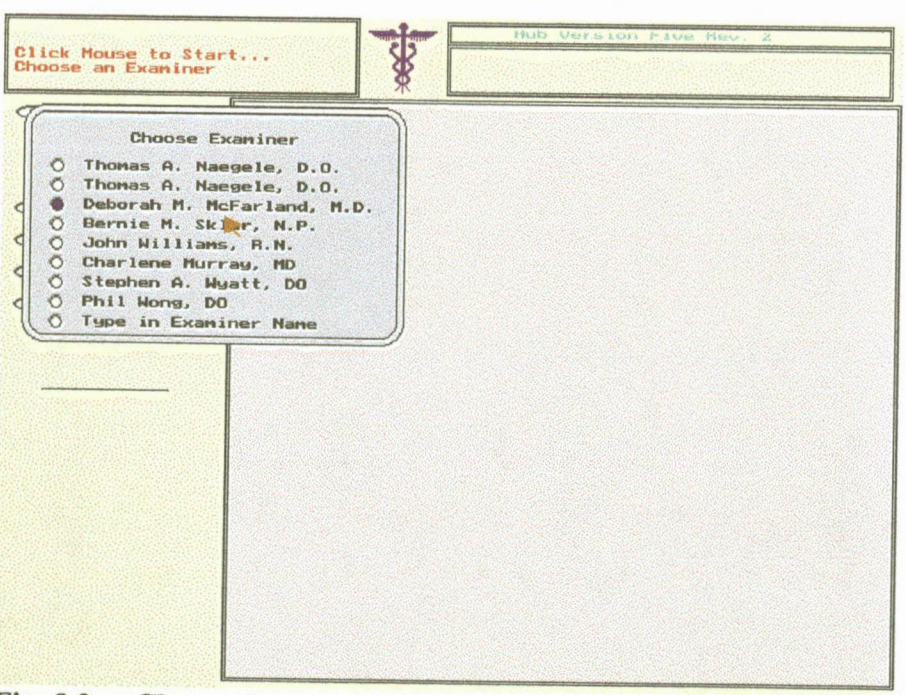


Fig. 8.3 Choose Examiner

- **Selecting a patient** – From the menu on the left-hand side of the screen, the *Select Patient* option should be selected. The surname of the patient for whom a consultation is about to be entered, should be typed into the *Enter Last Name, First Name* dialog box (Fig. 8.4). If it is an existing patient with previous consultations, the problem list for this patient will appear. For entering a new patient, select the *New Patient* option from the menu. The surname, first name, middle name, birth date, gender, patient number, and social security number of the patient need to be entered (Fig. 8.5).

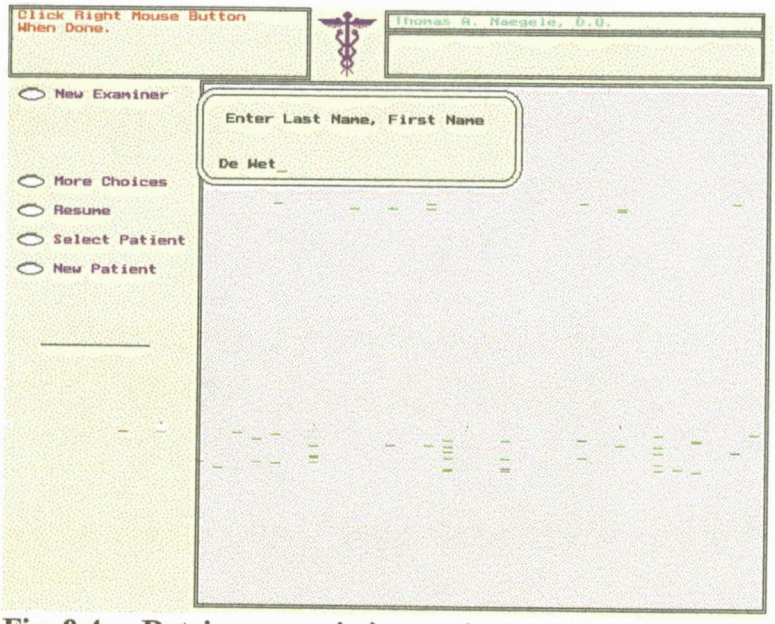


Fig. 8.4 Retrieve an existing patient

At this stage another section of the HUB is worth mentioning. When entering the program via the HubPaper executable file, as opposed to the Hub executable file, the administration part of the system will be invoked. It will be possible for the receptionist, for example, to enter all the patient demographics via this program. Previous medical notes can also be viewed. Another handy feature is the scheduling of patients. The receptionist may schedule patients for the day ahead (Fig. 8.6). When the physician invokes HUB and the *Select Patient* option is chosen from the menu, all the names of the scheduled patients will be listed. The physician only needs to select the appropriate patient, saving him/her the trouble of typing and searching for the correct information.

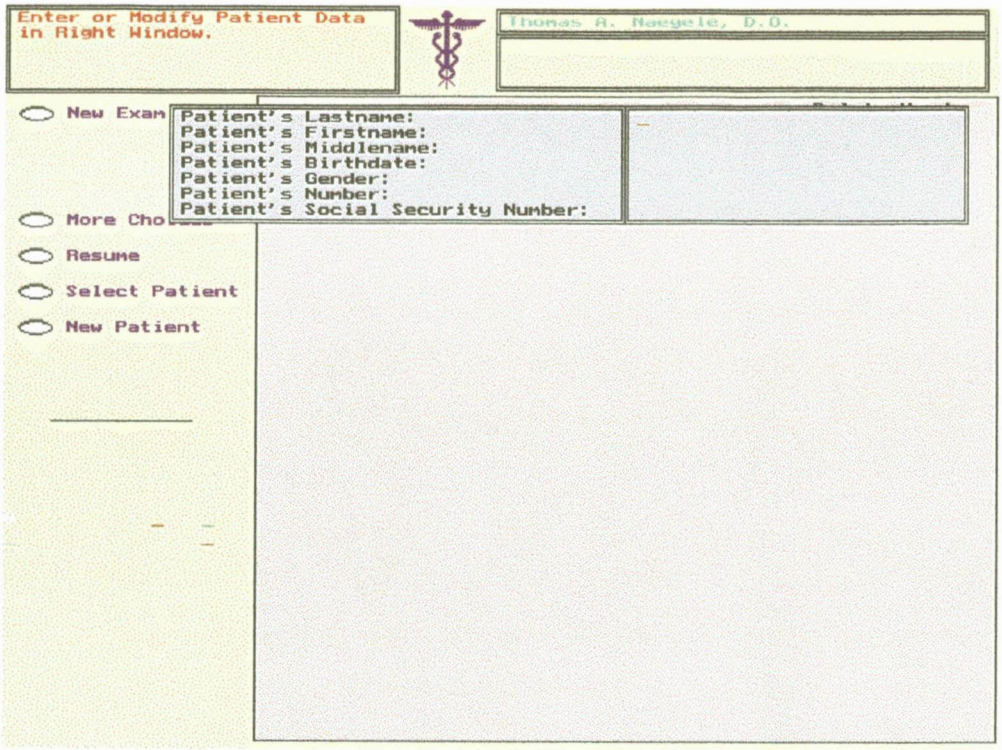


Fig. 8.5 Create a new patient

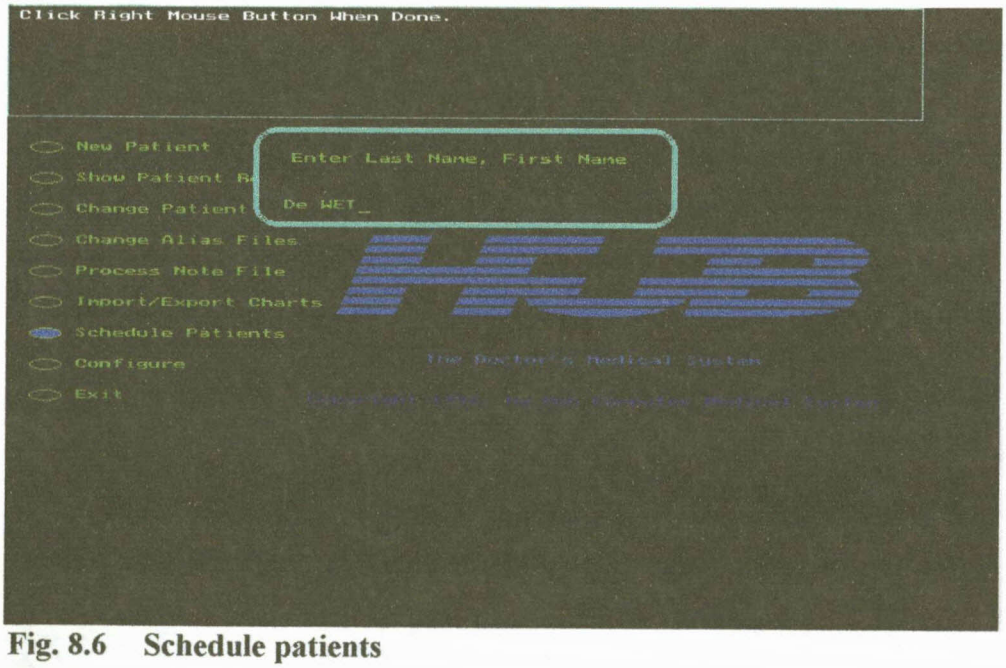


Fig. 8.6 Schedule patients

- **Foresighted Practice Guidelines** – After selecting a patient, a list of FPGs will appear in a window in the center of the screen (Fig. 8.7). From the menu on the left of the screen the *Timestamp* option should be chosen. Consequently the current date and time (the date of this new consultation) will appear at the top of the screen.

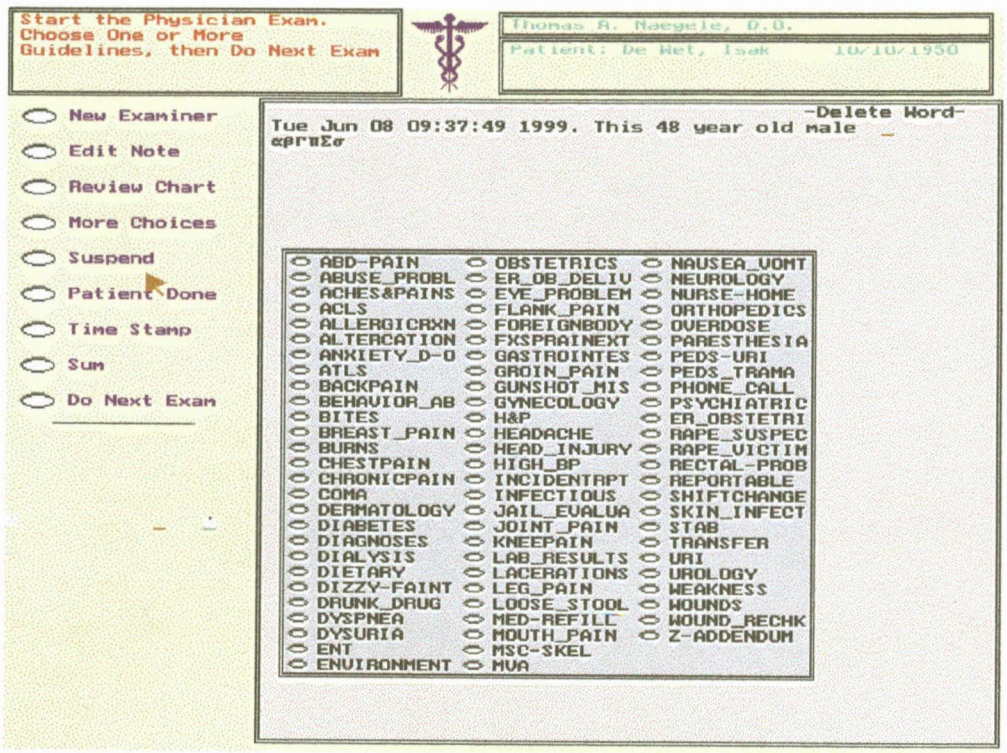


Fig. 8.7 List of Foresighted Practice Guidelines

After determining the patient's main complaint, the FPG(s) to be used in the consultation must now be selected. As an example, the first FPG, namely ADB-PAIN (Abdominal Pain) will be selected. The detail of the ABD-PAIN FPG will be presented on the screen in the information window in the center (Fig. 8.8).

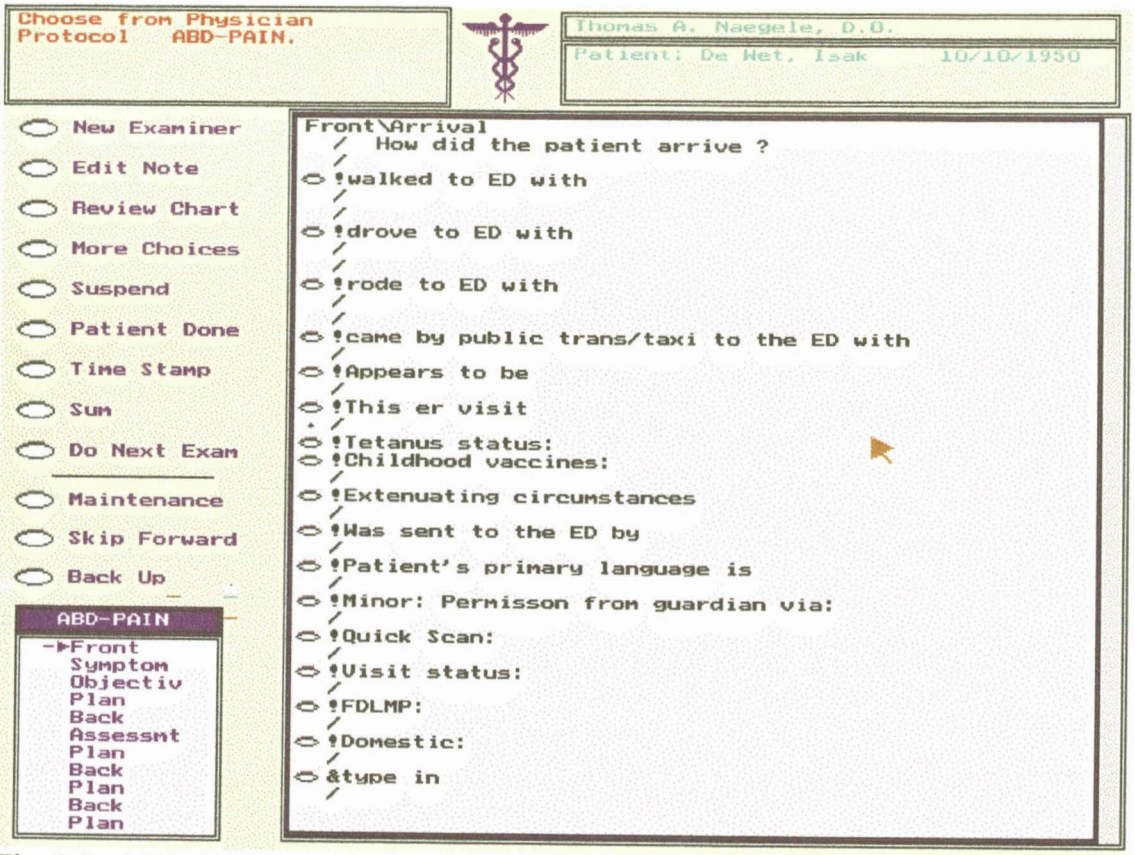


Fig. 8.8 ABD_PAIN Foresighted Practice Guideline

- **The consultation** – From now on the physician can proceed through the system at his/her own pace by making choices via the right mouse button. The guideline can be followed screen by screen, or the user may jump forwards and backwards and skip certain sections by selecting the main categories (e.g. Front, Symptom) in the block on the bottom left of the screen. To give an indication of the vast number of choices (data points) available, a heading *Chief Complaint of Chest Pain* in the *Symptom* category, typically contains around 100 data points [Naegele 1996].

As a result of the scope of the available choices, it will be impractical to present the reader with all the available screens/choices in the chosen ABD-PAIN FPG. An attempt will, however, be made to give a "feel" of the system by moving through the FPG selectively and consequently showing a few screen examples.

Referring to the FPG in Fig. 8.8, the first choices to be made concerns how the patient arrived at, in this case, the Emergency Department. When selecting the "drove to ED with" option, a window with sub-choices (Fig. 8.9) will appear.

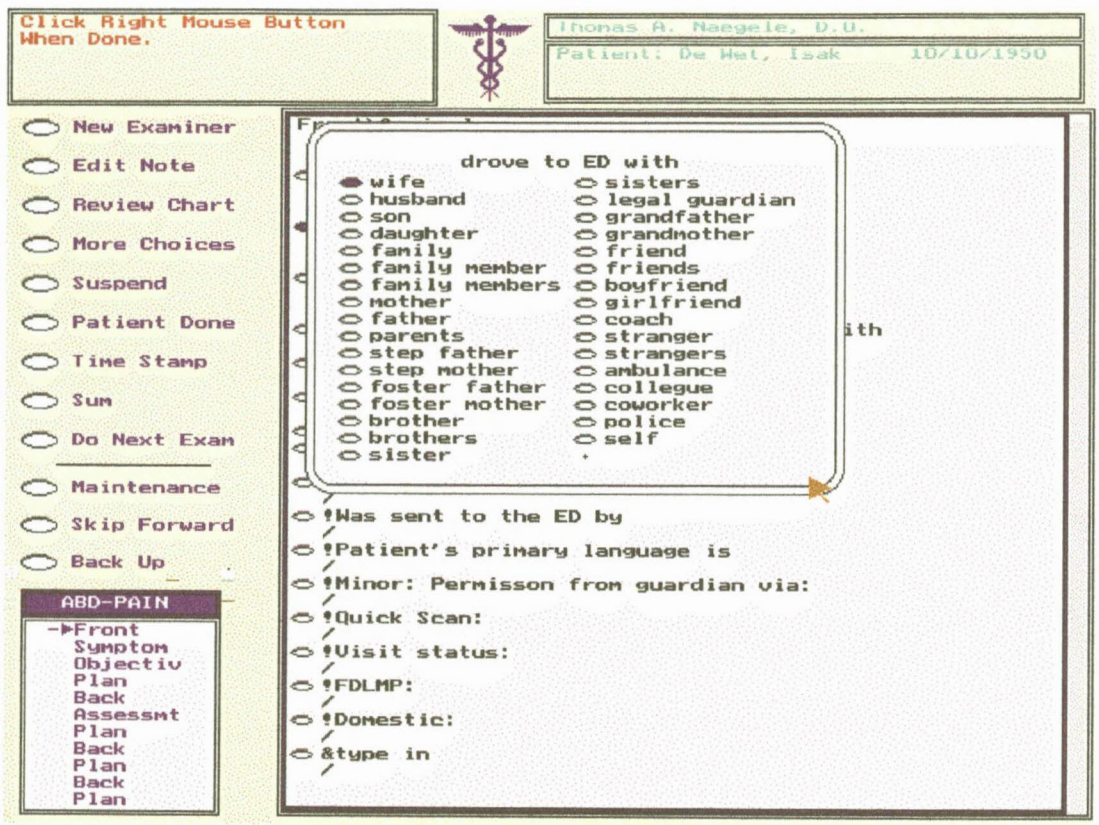


Fig. 8.9 Example of a Front of the Chart screen

The other available choices on the screen may be chosen selectively, for example "Appears to be", where two of the sub-choices are "anxious" and "in pain". Moving to the Symptom-part of the FPG, one of the choices available is "Complains of". Fig. 8.10 shows the sub-choices available in this case.

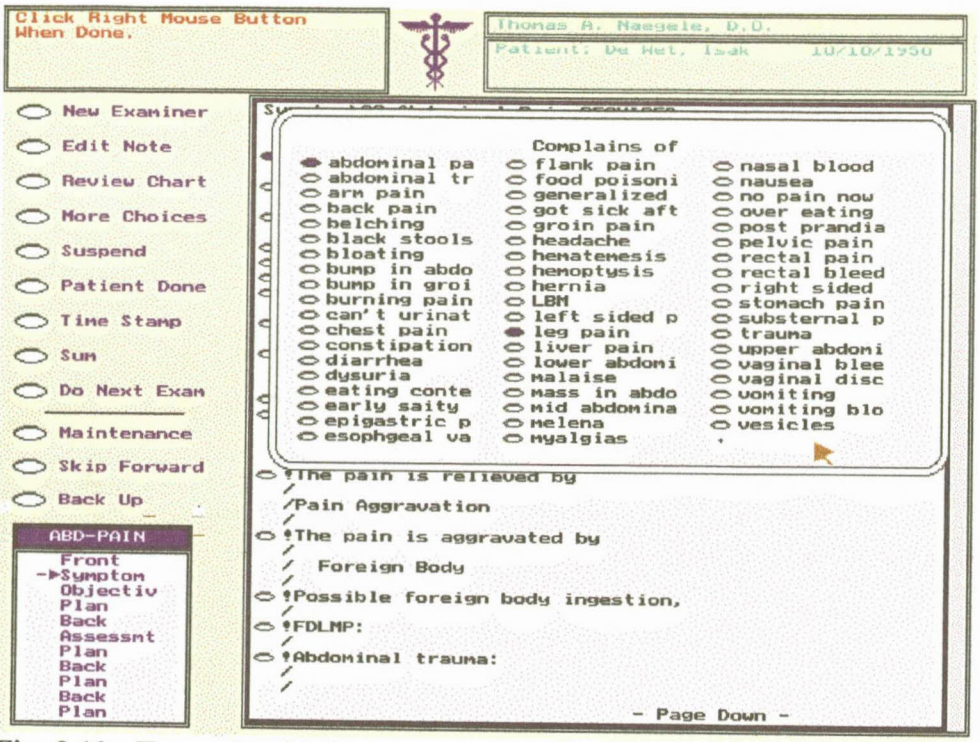


Fig. 8.10 Example of a Symptom screen

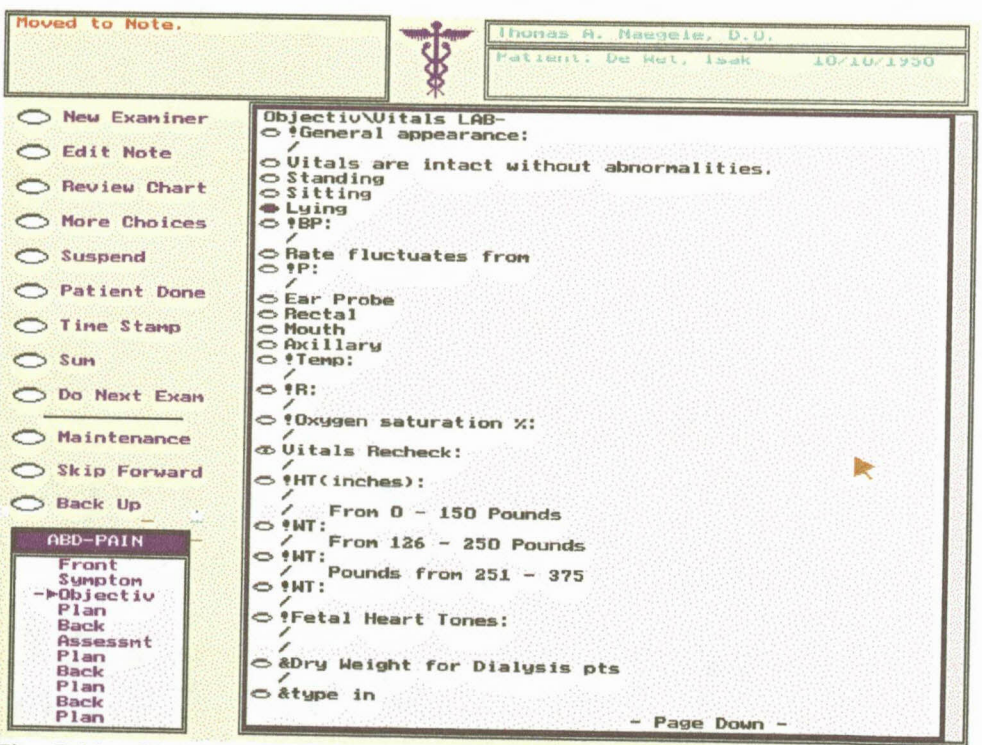


Fig. 8.11 Objective/Vitals screen

When moving on to the Objective part of the FPG, Fig. 8.11 illustrates one of the screens, namely the Objective/Vitals screen. Here the vital information, for example blood pressure and temperature, can be entered for a patient. Two examples of screens covering the Plan part of the FPG, are presented in Fig. 8.12 and Fig. 8.13. Fig, 8.12 presents the physician with a list of abdominal pain related medication, while Fig. 8.13 is a Reminder screen.

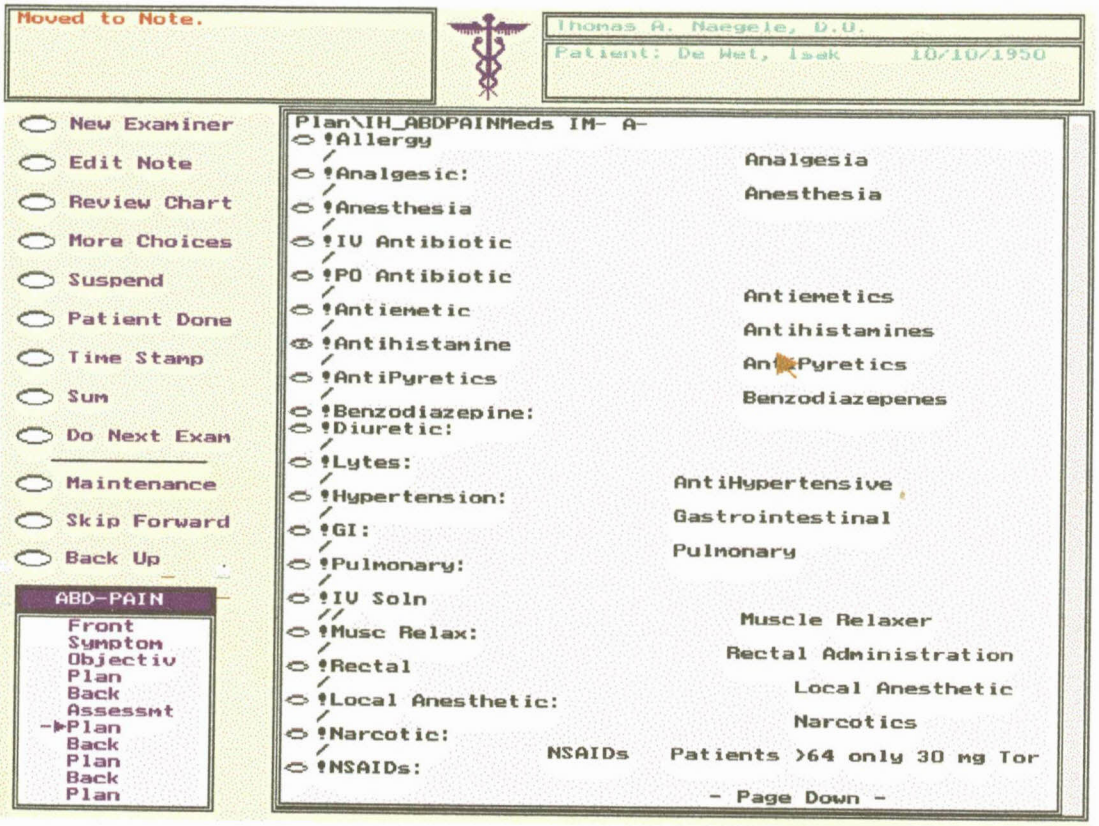


Fig. 8.12 Example of a Plan screen listing abdominal pain related medication

An example of the choices pertaining to the Back part of the FPG is contained in Figure 8.14. This screen shows the sub-choices in answer to the: "Suspect problem is associated with" option. Other options on the screen relate to all the different issues that have been discussed with the patient regarding his/her suspected illness, and what the patient understood from explanations given.

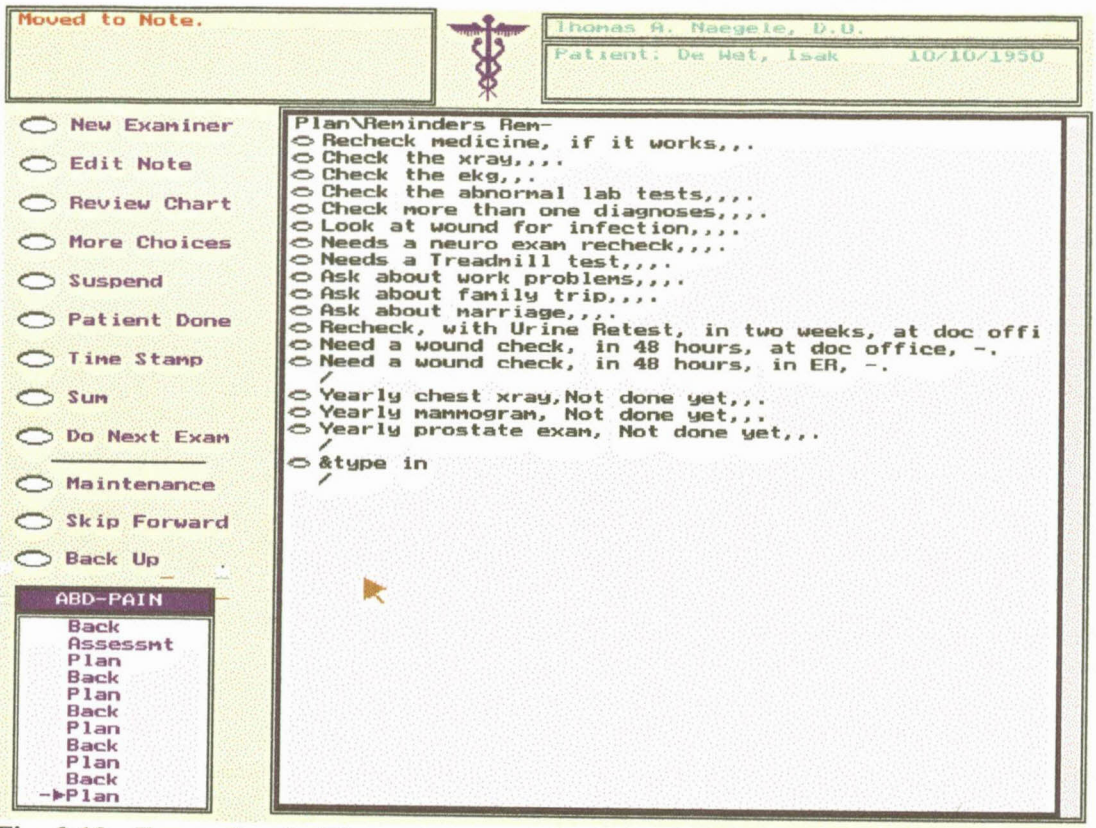


Fig. 8.13 Example of a Plan screen containing Reminder information

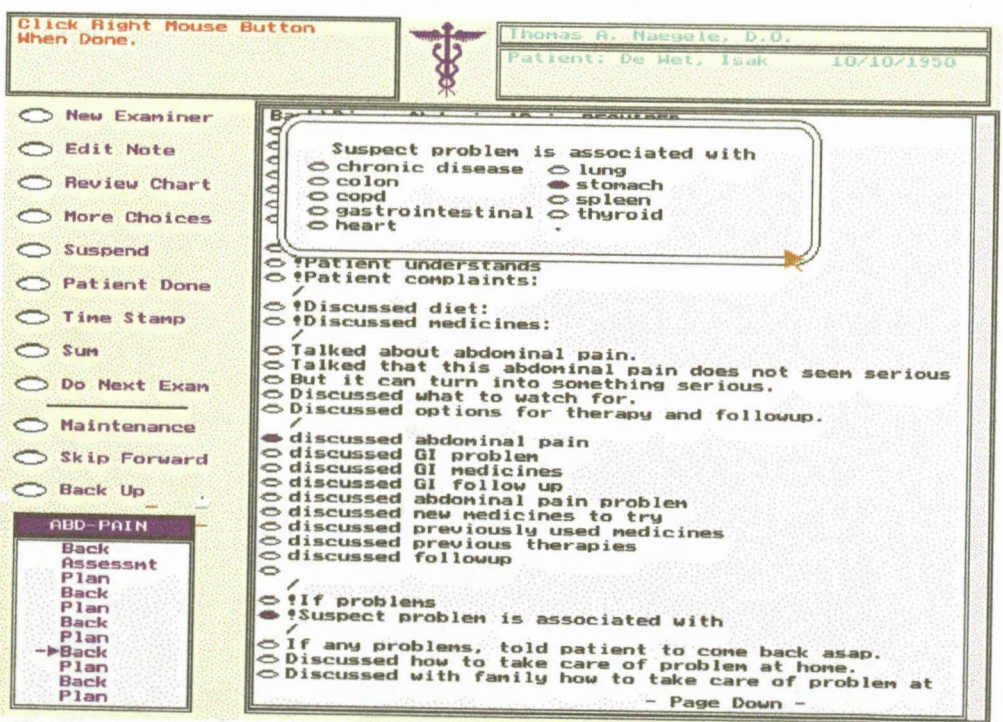


Fig. 8.14 Example of the choices on the "Back" part of the FPG

When the assessment needs to be made, Fig. 8.15 presents an example of one of the screens presented to the user.

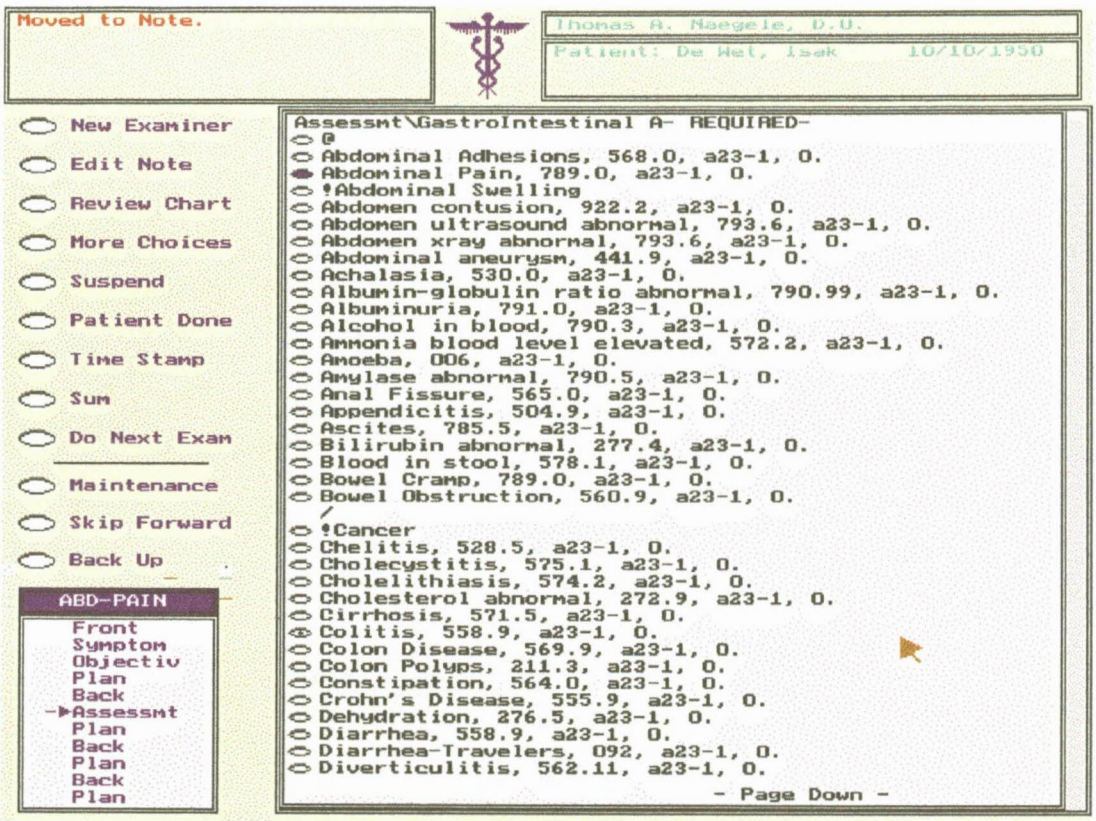


Fig. 8.15 Example of an Assessment screen

When satisfied that the consultation is concluded, the *Patient Done* option on the menu may be selected.

- **Finalising the consultation** – After selecting the *Patient Done* option on the menu, there might still be some remaining tasks. If the physician navigated through the system quickly and missed some of the required choices for the specific guideline, the missing choices will now be brought to his/her attention in a window (Fig. 8.16). The physician then has to click on each of these "missing links" to be returned to the appropriate screens. When all these links are handled, the resultant medical note will be displayed (Fig. 8.17). The user will be given a choice to print out the note and all the appropriate forms. After that a new patient can be selected, or the application may be closed. It is also important to note that a note can be discarded at any time during

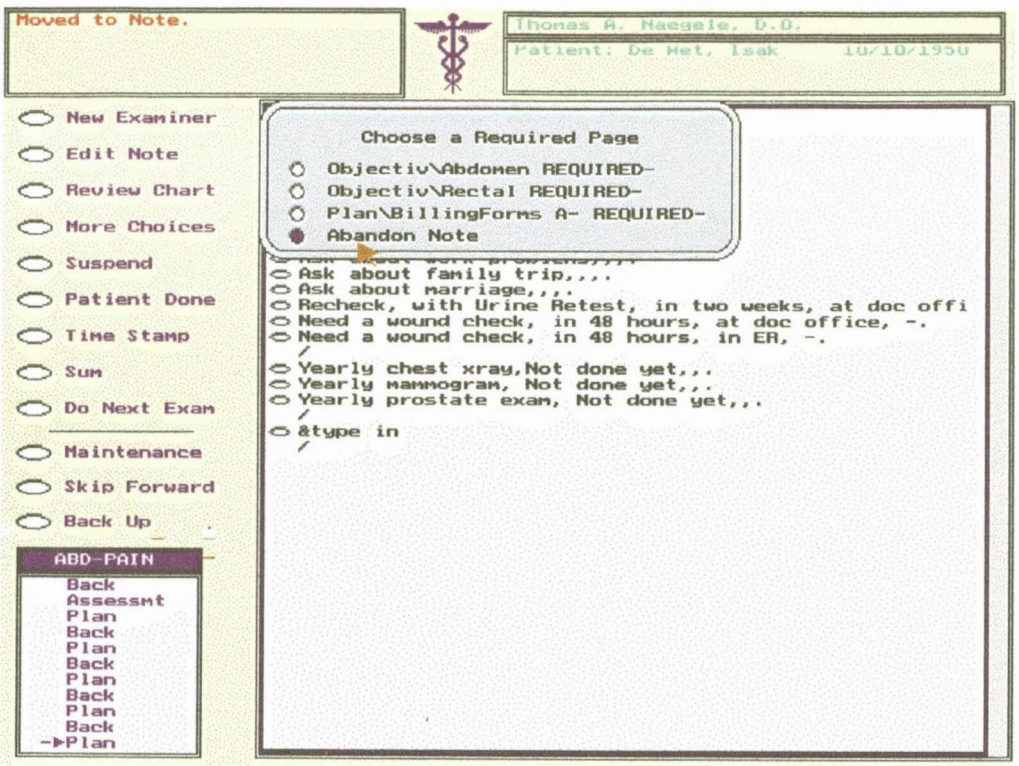


Fig. 8.16 Required screens that need to be filled in

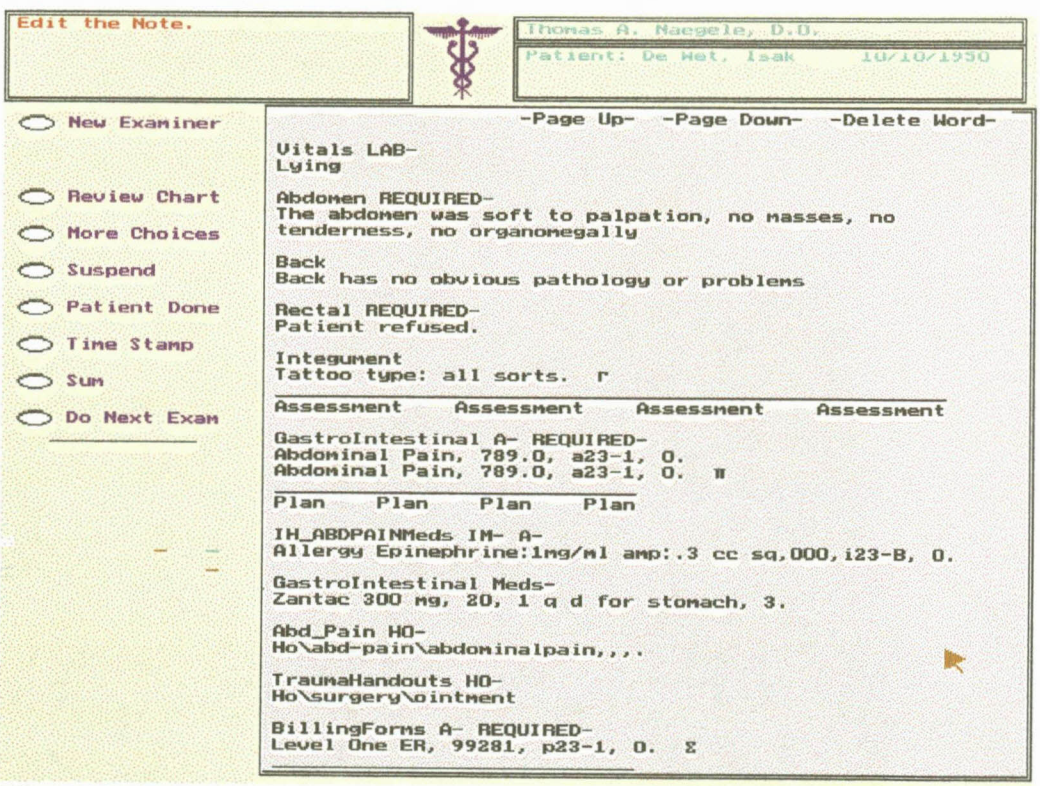


Fig. 8.17 Hub Medical Note

the consultation by simply selecting the *Suspend* option. Another way of discarding the note is to select the *More choices / Abandon note* option from the menu.

8.5 Summary

In this chapter the reader was introduced to the HUB Computer Medical System. An overview of the system was given and three file structures used by HUB were discussed. The chapter was concluded with a description of the system, combined with a few HUB screens.

In Chapter 9 the evaluation processes and results for the second prototype, as well as for the HUB Computer Medical System, will be described.

Chapter 9

Evaluation of Second Prototype and HUB system

9.1 Introduction

In the previous two chapters the second and third (HUB) prototypes were discussed in depth. In this chapter the evaluation procedures as well as the evaluation results regarding these two prototypes will be discussed.

9.2 Evaluation procedures

In Chapter 6 three evaluation procedures were employed to evaluate the first prototype, namely query techniques, heuristic evaluation, and usability testing. In this chapter query techniques will be applied to evaluate the second prototype and the third alternative, the HUB Computer Medical System. The heuristic evaluation and usability testing methods will then further be applied to the second prototype, following the same guidelines as set in Chapter 6. The reader is, therefore, referred to Chapter 6 for the theory behind the evaluation procedures, as they will not be repeated here.

9.3 Query techniques

This section will commence with a discussion on the planning that was involved in applying query techniques as an evaluation method to the second prototype and the HUB. The evaluation process will then be explained, followed in turn by the evaluation results of the second prototype and the HUB Computer Medical System.

9.3.1 Planning the evaluation procedure

In the middle of March 1999 the Department of Family Medicine at the University of the Orange Free State again hosted a refresher course for general practitioners. This course took place at the Medical Faculty of the above-mentioned university. This was deemed to be an ideal opportunity to evaluate the second prototype and the HUB system, as the attending physicians represented physicians from across the country (some even came from Namibia).

As soon as the second prototype was ready to be evaluated, an installation program was created for it. Twenty sets of installation disks were also prepared. The program was then installed on the computers in one of the computer laboratories of the Department of Computer Science and Informatics at the University of the Orange Free State, where the evaluation was due to take place.

At this stage a very important aspect regarding the HUB Computer Medical System must be addressed. The available HUB package was a demonstration kit. It was distributed with an encryption key that is plugged into the printer port to ensure use of the system on only one computer at a specific time. The consequence for the research was that the HUB could not be evaluated in exactly the same manner as the second prototype. For evaluation purposes the computer on which the system was originally installed, was also placed in the above-mentioned laboratory. The system was, therefore, available for evaluation on only one computer in contrast to the twenty computers available for the evaluation of the second prototype.

With the systems installed and ready for evaluation, evaluation forms were drawn up. The evaluation form used for the first prototype was used as a starting point (refer to section 6.3.1). As far as the second prototype was concerned, basically the same questions were asked, with the exception of a few questions that were added due to the changes that occurred in the new prototype. Similarly, the evaluation form directed towards the HUB system was appropriately adapted. Refer to Appendix E for examples of these evaluation forms.

In order to facilitate the evaluation, a typical consultation was drawn up with the assistance of personnel at the Department of Family Medicine. Their participation ensured that the data was medically viable. Separate consultations were constructed for the second prototype and the HUB. Constructing the consultation for the second prototype was done in considerable detail to ensure that the evaluators would explore all the different and available paths and screens that the system presented. Due to the magnitude of options available in the HUB system, the consultation prepared for this system was done in less detail. Copies of these consultations can be viewed in Appendix J.

At the start of the Family Practitioners' course on Monday, 15 March 1999, volunteers were asked to attend an evaluation session scheduled at the Department of Computer Science and Informatics for Wednesday, 17 March 1999, at 17:00. Due to technicalities, as far as the course was concerned, only ten physicians were able to attend the evaluation. In the following section the evaluation process itself will be discussed.

9.3.2 The evaluation process

With ten evaluators present, the session commenced with an on-line demonstration of the HUB Computer Medical System. The evaluators were then asked to rotate in order to give each one a chance to personally test the HUB system. The two evaluation forms, along with the consultation examples, were handed to each evaluator. In the mean time each one was assigned to a computer where they were guided through the second prototype, using the example consultation as a pathfinder. After testing both systems and filling out the evaluation forms, each attendee requested a set of installation disks in order to evaluate the system even further in their own time. The rest of the sets of disks were handed to five more interested course attendants the next day, while the remainders were given to general practitioners at random. Eventually twenty evaluation forms could be used for evaluation. The HUB system was also demonstrated to ten more evaluators at a later stage.

9.3.3 Evaluation results of the second prototype

The evaluation results of the second prototype are deemed to be of the utmost importance when considering a model for an acceptable EPR system in general practice. The reason is that the evaluators had a hands-on experience with this prototype – they were able to use the system personally, some for two hours, while others had the system at their disposal in their homes/practices for more than a month. To emphasize this point even further, one of the evaluators physically used the prototype in his home-practice for consultations during this whole period before completing the evaluation form. This is in contrast to the evaluation process of the first prototype, where the physicians were only presented with an on-line demonstration of the system. The following results will, therefore, give practical, first-hand advice/feedback to indicate how far to go towards the "ultimate" EPR system.

Table 9.1 represents a summary of the results of the evaluation forms as completed by the evaluators of the second prototype. It is in a similar format as Table 6.1, where the evaluation results of the first prototype were summarised. These results are presented visually in Appendix M. The results presented in Table 9.1 will now be discussed in detail.

Considering the positive feedback on the second prototype, it is first of all gratifying to note that 60% of the evaluators indicated that it was very easy to move around among different screens (30% responded to "good" and 10% to "fair"). The word *gratifying* is used, as this is a first indication that the second prototype is an improvement on the first one. Moving through too many screens was one of the major problems identified during the evaluation of the first prototype. Closely related to this point is the 50% "excellent" response to indicate that the system provides for adequate freedom and does not force the user into following predefined sequences.

Another very positive observation pertains to user interface aspects. Taking both the responses of "good" and "excellent" into account, 85% of the evaluators indicated that the user interface was visually well organised and acceptable, and 70% indicated that the

EVALUATION QUESTION	NON-EXISTENT(%)	POOR (%)	FAIR (%)	GOOD (%)	EXCEL-LENT (%)
The task of registering a family is easy			10	45	45
There are convenient means to search for a family			5	37	58
The task of registering a new patient is easy				47	53
There are convenient means to search for a patient.			16	26	58
The system provides for all the basic clinical services rendered by a general practitioner.	5	5	32	21	37
The system corresponds closely to the old way of doing things.		10	30	45	15
The system is an improvement on the manual system.		5	32	37	26
The system ensures that the entered data is valid to the greatest possible extent.		5	11	26	58
The system provides me with sufficient information regarding the clinical records in my practice.			6	44	50
The system provides for the total medical record.			16	42	42
The system provides for too much detail.	16	16	21	31	16
The system provides for too little detail.	47	11	37		5
It is easy to find what I need to do in the system.		10	15	35	40
Easy to move among different screens.			10	30	60
The system provides me with adequate freedom and does not force me to follow predefined sequences.		10	15	25	50
The amount of typing I need to do is acceptable.	11	26	37	11	15
The interaction with the system is clear and understandable.			30	20	50
The user interface is visually well organised and is acceptable.		5	10	25	60
My productivity will increase by using the system.	6	11	39	28	16
Overall the system is easy to use.			20	25	55
Overall the system is easy to learn.			10	35	55
Overall the response time of the system is good.	5		10	30	55
I shall have more time for patient care during consultations.	21	26	37	5	11
I shall be willing to personally use this system.		5	21	26	48
I shall be willing to personally use this system in the presence of the patient.	6	22	33	16	22
The use of the system will maintain the relationship of trust with the patient.		16	28	33	22
This system is precisely what I envisioned an electronic patient record system to be.		11	28	44	16
I am willing to participate in the establishment of a generally acceptable electronic patient record system in the future.	5	11	16	21	47

Table 9.1 Results of the evaluation of the second EPR prototype system

interaction with the system was clear and understandable (in contrast to 61% who agreed to that regarding the first prototype). Seventy-five percent also indicated that it was easy to find what they needed to do in the system. This brings the aspects of *ease of use* and *ease of learning* to mind. Ninety percent of the evaluators had no trouble whatsoever in learning how to use the system (sixty-nine percent did not have trouble with the same task regarding the first prototype). Eighty percent of them indicated that the system was overall easy to use. This is an improvement of 21% in comparison to the evaluation of the first prototype where the corresponding figure was 59%. Still on the subject of ease of use, the tasks of registering a family (90%), searching for a family (95%), registering a new patient (100%) and searching for a patient (84%), seem to have given the evaluators no trouble at all. (The "excellent" and "good" responses were taken into account in the indicated percentages above). All these aspects pertaining to the family and patient fared much better in the second prototype than in the first. From the above a fair assumption can be made that the user interface seems to have improved vastly from the first prototype and complies with user expectations.

For a computer system to be acceptable, it must at least be an improvement on the way things were done manually. Twenty-seven percent of the evaluators perceived the EPR prototype to be an *excellent* improvement on the manual system. Thirty-seven percent felt that it was a *good* improvement, 32% that the improvement was *fair*, while only 5% indicated that it was a *poor* improvement, or stated otherwise, no improvement at all. With 58% replying to *excellent* and 26% to *good*, there seems to be a vote of confidence in the prototype's ability to ensure the validity of entered data. The response time of the system is also perceived as being good to excellent (85%).

One of the indicators to determine the level of completeness of a computer system, is the scope of the information that it covers. Quite a few questions/statements were directed towards obtaining this information. To the statement "*The system provides me with sufficient information regarding the clinical records in my practice*", 50% of the evaluators answered "*excellent*", 44% "*good*", and 6% "*fair*". Eighty-four percent of the evaluators indicated that the system provided for the total medical record. An indication

that there is still some work to be done, can be found in the response to the statement testing the evaluators' opinions regarding whether the system provided for all the basic clinical services rendered by a general practitioner. Fifty-eight percent of them replied that this was the case. Ten percent, however, did not agree while 32% were unsure. The level of detail covered by the system received varying opinions. On the statement "*The system provides for too much detail*", 32% of the evaluators agreed, while 47% disagreed. Twenty-one percent did not choose either way. The contrary was tested as well in the statement "*The system provides for too little detail*". To this statement 48% felt that the system did not provide for too little detail, while only 5% disagreed.

As has been mentioned several times in this thesis, one of the pre-conditions for a successful EPR application is that the physicians should personally use the system. In comparison to the evaluation results of the first prototype where 47% of the evaluators replied that they would personally use the system, 30% were still unsure about it and 23% stated that they would not use the system themselves, it is positive to note that only 5% of the evaluators of the second prototype were unwilling to personally use the system. Seventy-four percent indicated that they would use the system, while 21% were unsure about it. The second prototype, therefore, seems to be a definite improvement on the first attempt, as more physicians are willing to try and put a hand to it. Having determined whether physicians would personally use the computer or not, the next step was to find out whether they would be willing to use the system in the presence of the patient. The response to this issue was a bit less positive, as 6% indicated that they would definitely not do it, 22% indicated that they might not do it, 33% were unsure about it, 16% felt that they were willing, and 22% that they would definitely be so brave as to use the system in the presence of the patient. In comparison to the results of the same evaluation question regarding the first prototype, it is interesting to note that the response is very similar. There seems, however, to be a slight shift towards not using the system in the presence of the patient which emerged after physicians had physically used the system. One of the possible reasons for this shift will be addressed in the next paragraph.

Closely related to the previous question, is the issue of maintaining the relationship of trust with the patient. Sixteen percent of the physicians still fear that this trust-relationship will be damaged, 28% are unsure, while 55% believe that the relationship will stand the test of time. The fear regarding the relationship of trust might be a reason for the reluctance regarding the use of such a system in the presence of the patient. The opinions regarding this issue did not vary substantially between the evaluation of the first and second prototypes.

As was mentioned in the evaluation of the first prototype system, one of the major concerns at that stage revolved around the amount of typing in the system. Although attempts were made to improve this issue in the design of the second prototype, this still seems to remain a concern. This is illustrated by the 11% of evaluators feeling that the amount of typing necessary in the system is unacceptable, 26% who feel unhappy with the amount of typing, 37% who are unsure about the issue, 11% who are reasonably happy with the typing, and 15% who are totally satisfied with the amount of typing expected of the user. Typing takes up time, especially when the "typist" is not experienced in the craft! Therefore, the reaction to the amount of typing is closely related to the statement "*I shall have more time for patient care during consultations*". This was a concern raised in the evaluation of the first prototype as well. As far as the second prototype is concerned, 47% do not agree with the above-mentioned statement, while only 16% are of the opinion that they would have more time for patient care when using an EPR system for consultations. Thirty-seven percent indicated a "*fair*" to this statement. As typing is related to time, time is also related to productivity, hence the 15 % of the evaluators who felt that their productivity would not increase as a result of using the EPR system. Forty-four percent were positive that their productivity might increase. This is a slight improvement on the evaluation of the first prototype where 36% felt the same way.

To conclude the discussion of Table 9.1 on a more positive note, the following must be said: although the second prototype EPR system does not appear yet to be precisely what the physicians envisioned an EPR system to be (60% felt that it was close, in comparison

to the 52% who felt the same way about the first prototype), 68% of the evaluators were willing to participate in the establishment of this ideal in future.

Other "first-appearing" additions/improvements mentioned in the comments section of the evaluation forms, include the following:

- The addition of a first name on the Patient screen
- Transferring the church denomination from the Family to the Patient screen
- Extending the search facility to facilitate searching on the first name, address, birth date, and medical aid
- Providing for printing facilities for the medical note, the reminder, and prescriptions, as well as a report facility for ad hoc queries for research purposes
- Extended e-mail facilities to include direct e-mail to patients, for instance for the sending of reminders.

The positive remarks concerning this prototype is summarised in Table 9.2.

	POSITIVE COMMENTS ON THE SECOND PROTOTYPE
1.	Very good step in the right direction.
2.	Good acquisition to the practice.
3.	Will initially affect the health care giver/patient relationships, but will, however, grow in its use in the practice.
4.	The EPR is already very useful.
5.	Provides many possibilities – would like to use it!
6.	System is quite good generally.
7.	Easier and more complete than manual system.
8.	Program is excellently compiled.

Table 9.2 Summary of positive comments on the second EPR prototype system

EVALUATION QUESTION	NON-EXISTENT(%)	POOR (%)	FAIR (%)	GOOD (%)	EXCEL-LENT (%)
The task of registering a new patient is easy.		33	67		
There are convenient means to search for a patient.		33	33	33	
The system provides for all the basic clinical services rendered by a general practitioner.			67		33
The system corresponds closely to the old way of doing things.	67	33			
The system is an improvement on the manual system.		67		33	
The system ensures that the entered data is valid to the greatest possible extent.	33		33	33	
The system provides me with sufficient information regarding the clinical records in my practice.			67	33	
The system provides for the total medical record.				33	67
The system provides for too much detail.					100
The system provides for too little detail.	67	33			
Basing a computer system on the FPG principle is acceptable.	33		67		
It is easy to find what I need to do in the system.	33	33			33
It is easy to move among the different screens.	33		33	33	
The system provides me with adequate freedom and does not force me to follow predefined sequences.	67	33			
The amount of typing I need to do is acceptable.		33		33	33
The interaction with the system is clear and understandable.		67		33	
The user interface is visually well organised and is acceptable.	33	67			
My productivity will increase by using the system.	33	33		33	
Overall the system is easy to use.		33	67		
Overall the system is easy to learn.	33		67		
Overall the response time of the system is good.		33	33	33	
I shall have more time for patient care during consultations.	33	33		33	
I shall be willing to personally use this system.	33		33	33	
I shall be willing to personally use this system in the presence of the patient.	33	33	33		
The use of the system will maintain the relationship of trust with the patient.			67	33	
This system is precisely what I envisioned an electronic patient record system to be.	67	33			

Table 9.3 Results of the evaluation of the HUB Computer Medical System

9.3.4 Evaluation results of the third alternative (HUB)

The two systems, namely the second prototype and the HUB, were presented to the evaluators on equal footing. The only difference was the fact that the HUB was available on one computer only, in contrast to the second prototype that was available on all the laboratory computers. Despite the relatively equal attention given to each system, the evaluators approached the HUB differently. Where they were all more than willing to complete an evaluation form for the second prototype, only three of the evaluators bothered to do the same regarding the HUB. The rest used the area at the end of the HUB evaluation form for general comments and wrote comments like "*System has merit, but too much detail!*" and "*Rather leave this – it is too cumbersome*". With only three evaluators fully completing the evaluation form, Table 9.3 does not give a representative view as far as the evaluators' opinions are concerned. The table is nevertheless included for interest sake and to allow for consistency in the evaluation of all three systems. The comments on the HUB are summarised in Table 9.4.

	COMMENTS ON HUB
1.	The system has merit, but too much detail!
2.	Not applicable to us.
3.	Screens a bit complicated at the beginning. Option to enter less information does not really exist, as there are too many required fields.
4.	Thought processes are being dictated by the computer and not by the patient.
5.	Rather leave this option – it is too cumbersome.

Table 9.4 Summary of comments on the Hub Computer Medical System

9.4 Heuristic evaluation

The same list of ten heuristics [Dix 1998] that were used in Chapter 6 will now be used in an attempt to uncover usability problems associated with the second prototype.

- **Visibility of system status** – As was the case with the first prototype, the second prototype supports visibility of the system fairly well. The status bar at the bottom of every screen ensures that the appropriate message appears as soon as any task/operation has been completed (refer to section 6.3.2.1). Therefore the second prototype is perceived to give the user appropriate feedback within reasonable time to keep him/her informed.

- **Match between system and the real world** – The feedback received from the evaluation forms filled in as part of the evaluation process of the first prototype (refer to section 6.3.1) were used as guidelines for the type of information to be included in the second version of the EPR. This also applies to the terminology used. The continuous walkthrough evaluation sessions held with a physician during the development of the second prototype also ensured that real-world conventions were followed for information to appear in a natural and logical order.

The second prototype was also based on the SOAP model, as was the first prototype. This facilitated in providing the user with a familiar environment.

A major change was made to the first prototype to facilitate (among other reasons) the match between the system and the real world. Tab-sheets were used to represent the different screens of the system. These tabs resemble real world paper folders – the format of the manual paper patient records currently in use by a great number of general practitioners (as was learnt from the questionnaires discussed in Chapter 4). The tab metaphor (refer to Chapter 1), therefore, greatly enhanced the match between the second prototype and the real world.

- **User control and freedom** – Being a prototype system, it was decided not to provide for explicit undo and redo actions. Users, however, often choose system functions by mistake. In order to minimize the disruptions caused by erroneous actions, confirmation dialogues were introduced more extensively to the second prototype in comparison to the first. The user is asked to confirm his/her intention of

saving a consultation – with the option of canceling the intended saving operation. The same applies to leaving the system (pressing the exit-button). Therefore the user is given more control than was the case in the first prototype.

The second prototype fairs much better with regard to user freedom when compared to the first prototype. This can be contributed mostly to the use of the tab-method, as was mentioned before. The user is allowed to move among the different SOAP screens in any order and is not committed to any entered information until a specific "Confirm this Consultation"-button is pressed. The different screen options are also constantly visible to the user, giving him/her a sensation of being in control when he/she is able to visualize the scope of the system.

The placement of the Exit-button at the bottom of the screen, visible and reachable from every screen, also enhanced user freedom.

In the first prototype the user was prohibited from making any changes/additions to a consultation after it has been saved. The same principle was adhered to in the second prototype for medico-legal purposes. Provision was, however, made in the second prototype to facilitate the linking of additional information to an existing consultation at a later stage. The Modify function provides for selecting an existing consultation (by date and time) and to attach a note to it.

The second prototype, therefore, has come a long way in providing user control and freedom when compared to the first prototype.

- **Consistency and standards** – The heuristic evaluation performed on the first prototype highlighted specific consistency and standard problems. These problems seem to have been addressed and solved in the design of the second prototype. These include:

  - The colour inconsistencies were removed. All the grids are teal-coloured.

- Bitbuttons are used for all the action buttons (e.g. OK, Clear), while normal buttons are used for the navigational buttons (e.g. Illness, Operations).
- A consistent "yyyy/mm/dd" date format is used throughout the system.

Aspects like system feedback (status bar messages and error message dialog boxes), screen layout, and general functioning procedures are perceived to be consistent (refer to section 6.3.2.1). Attention should, however, be given to the inconsistent use of check boxes on the Examination screen (General Appearance section) and the Systemic History screen.

- **Error prevention** – The same basic principles that were applied to the first prototype to prevent errors were also applied to the second prototype. These include the provision of choices to the user to select from, preventing the allocation of duplicate family account numbers, patient identification numbers, etc., and confirmation requirements when deleting an item (to prevent typing errors). Additionally, the user of the second prototype is expected to confirm his/her action when leaving the system. This would cater for accidental pressing of the Exit-button.

The second prototype also provides for numerous default values/choices. The most probable/often used choice is displayed in a combo box. The user, therefore, does not have to bother making a choice (provided his intended choice is displayed in the combo box!). Less user actions result in less user errors. Examples include the default "consultation" in the "Nature of consultation" field on the History screen and the problem date (default is current consultation date) on the Assessment screen.

In two cases where the user has to enter dates (problem-viewing and follow-up visit) a graphical calendar is provided to relieve the user from typing in the date and possibly making typing/date format errors. The provision of an edit mask for entering a patient's blood pressure can also be viewed as an error prevention method.

These examples indicate that, as was the case in the first prototype, an effort was made to prevent errors from occurring when using the second prototype.

- **Recognition rather than recall** – The second prototype is perceived to comply with this principle adequately (as was the general perception with the first prototype as well). The reasons are as follows:

  Users are provided with valid choices in the form of combo box lists or grids. In stead of recalling the valid choices, the user simply recognises them. Newly added, modified or deleted items are immediately reflected on grids to remind the user that the action has been performed and executed correctly. Messages in the status bar also remind the user of the last action performed in comparison to recalling the previous action.

  Users are relieved from the memory burden of recalling the valid date format to use as it is displayed next to the entry field. Graphical calendars are provided where the user has to choose the problems' display-periods and a follow-up consultation date. This facilitates choosing the date in a "fun-way" using the mouse (in contrast to typing it in and concentrating on the valid date format). Another example where recognition is facilitated, is the provision of the human bodily systems in checklists and the listing of general appearance options. No recall is necessary.

  As was mentioned before, more default values may be found in the second prototype than in the first. These defaults also facilitate recognition rather than recall. Additional to the dynamic display of a patient's birth date after entering an identification number (present in the first prototype as well), the patient's age is also displayed.

  During heuristic evaluation the absence of hints was mentioned as a shortcoming of the first prototype. This aspect has been adequately addressed by providing hints throughout the second prototype. Another problem associated with the first prototype

was the necessity to retype the residential address on the Patient screen even if it was identical to the address on the Family screen. The second prototype attempted to prevent any form of retyping. After entering the residential address on the family screen, the user has the option of copying the residential address to the postal address by simply pressing a button. The residential address on the Family screen will also be transferred as default to the Patient screen. The user has the option of changing it by also pressing a button.

Other examples of the second prototype's improvement on recognition rather than recall include the patient name appearing on every screen as a reminder to the physician, the appearance of the red allergy grid on both the Patient and Plan screens and the query facility. This facility enables the physician to make inquiries regarding other patients while being busy with a patient. When returning to the current patient, the system will return to the state in which it was before the interruption, relieving the physician of the burden of remembering where he left off. Being a prototype, it was again decided not to provide a formal help facility, as was decided on the matter in the case of the first prototype.

Generally, therefore, the second prototype complies favorably with "recognition rather than recall".

- **Flexibility and efficiency of use** – The second prototype also provides for flexibility and efficiency of use in the form of accelerator keys (refer to section 6.3.2.1). No further proof of complying with these aspects could be identified.

- **Aesthetic and minimalist design** – The feedback received from the physicians during the evaluation of the first prototype (Chapter 6) and the continuous cognitive walkthrough sessions held, greatly contributed towards preventing the inclusion of irrelevant information or information that is rarely needed. The task analysis at the end of Chapter 9 will further throw light upon this matter.

- **Help users recognise, diagnose, and recover from errors** – The error messages displayed while using the second prototype are expressed in clear plain language. The messages generally indicate the problem in a precise manner, but as was the opinion regarding the first prototype's compliance to this aspect, solutions should be provided constructively.

- **Help and documentation** – When handed a set of installation disks for installing the second prototype, accompanied by the minimum of instructions and help, not one of the twenty physicians used to evaluate the second prototype could not install the system, run it or use it. Admittedly some minor questions regarding specific sections of the system occasionally appeared, but as a whole the system appeared to be simple enough for a physician to use. (The hints introduced in the second prototype might have contributed to this ease of use). Although it was recognised that the eventual EPR system should provide for an on-line help facility, the same decision that was taken regarding the provision of help in the case of the first prototype, was applied to the second prototype (refer to section 6.3.2.1).

This concludes the heuristic evaluation of the second prototype. Generally, the second prototype is perceived as being a great improvement on the first prototype when considering the ten heuristics above. In the following section the usability testing procedures applied to the second prototype will be discussed.

9.5 Usability testing

In Chapter 6 usability testing was performed on the first prototype by utilising the usability principles summarised in Table 6.2. First, qualitative evaluations were performed for each usability principle. It was explained how observational techniques were subsequently used to obtain empirical data to perform a more quantitative empirical evaluation method. It was also stressed that the empirical evaluation results would only become meaningful when the first and second prototypes were to be compared to each other. These quantitative evaluation results are, therefore, presented in this chapter.

This section will, therefore, commence with a brief explanation of the procedures followed for the usability testing of the second prototype. This will be followed by a qualitative evaluation of each of the usability properties. The results of the empirical testing (also organized under the headings of the usability principles) will then be presented in tabular format and discussed. A task analysis will conclude the usability testing, as was the case in Chapter 6.

9.5.1 Usability testing procedures

The reader is referred to section 6.3.3.1 where the procedures followed for the usability testing of the first prototype were outlined. The same ten subjects that were recruited at that stage to participate in the evaluations using observational techniques, were recruited for the second prototype as well. In order to present a "comparable environment" the preparation methods and evaluation sessions were conducted in exactly the same manner for both the prototypes.

The results of the usability testing regarding the second prototype will now be presented.

9.5.2 Results of usability testing

In presenting the results of the usability testing, a qualitative evaluation will first be given for every usability principle. The reader is referred to Chapter 6 concerning the remarks on the qualitative evaluation method.

As was mentioned in Chapter 6, where possible (and appropriate) a quantitative (empirical) evaluation was performed to test the prototype's conformance to the usability principles. This was done by measuring certain criteria (as listed in Chapter 6).

Although a detailed statistical discussion falls outside the scope of this thesis, it was deemed necessary to explain the basic statistical methods and assumptions used for drawing conclusions from the data collected. This will be done by using the results of the

empirical test concerning the *time duration to create a consultation* as example. In presenting this discussion, the methods suggested by Dix *et al.* [1998] were applied.

The first step that was taken in this empirical evaluation method was to form a hypothesis: what would the likely outcome of the test be? The null hypothesis in this case would be: *There is no difference between the two prototypes' adherence to the task conformance usability property.* The independent variables for the test were the prototype, the subject and the transfer of learning. The dependent variable tested was the time duration to create a consultation. The detailed results of the test are presented in Table 9.5.

		(1)	(2)	(3)	(4)	(5)
Subject number	**Presentation order**	**First (s)**	**Second (s)**	**Subject mean**	**First (1) - (3)**	**Second (2) - (3)**
1	FS	203	184	194	10	-10
2	FS	296	195	246	51	-51
3	FS	342	259	301	42	-42
4	FS	290	174	232	58	-58
5	FS	335	250	293	43	-43
6	SF	303	240	272	32	-32
7	SF	184	153	169	16	-16
8	SF	303	235	269	34	-34
9	SF	340	322	331	9	-9
10	SF	290	247	269	22	-22
Mean		289	226	257	31	-31
S.D.		54	50	49	17	17
S.E.D.	23			**S.E.**	5.41	
Mean/S.E.					5.79	($p < 1\%$)

Table 9.5 Test results determining the time duration to create a consultation while using the first and second prototypes.

Table 9.5 shows the set of results for the ten subjects that participated in the tests. Figure 9.1 graphically depicts the means and standard deviations of this data. Referring to Table 9.5, the first five subjects had the first prototype presented first (order FS) and the last five had the second prototype presented first (order SF). (It was mentioned in Chapter 6

that this was done to avoid the effect of transfer of learning. The involvement of learning was also the motivation for using a within-groups design, in which each user performs using both prototypes).

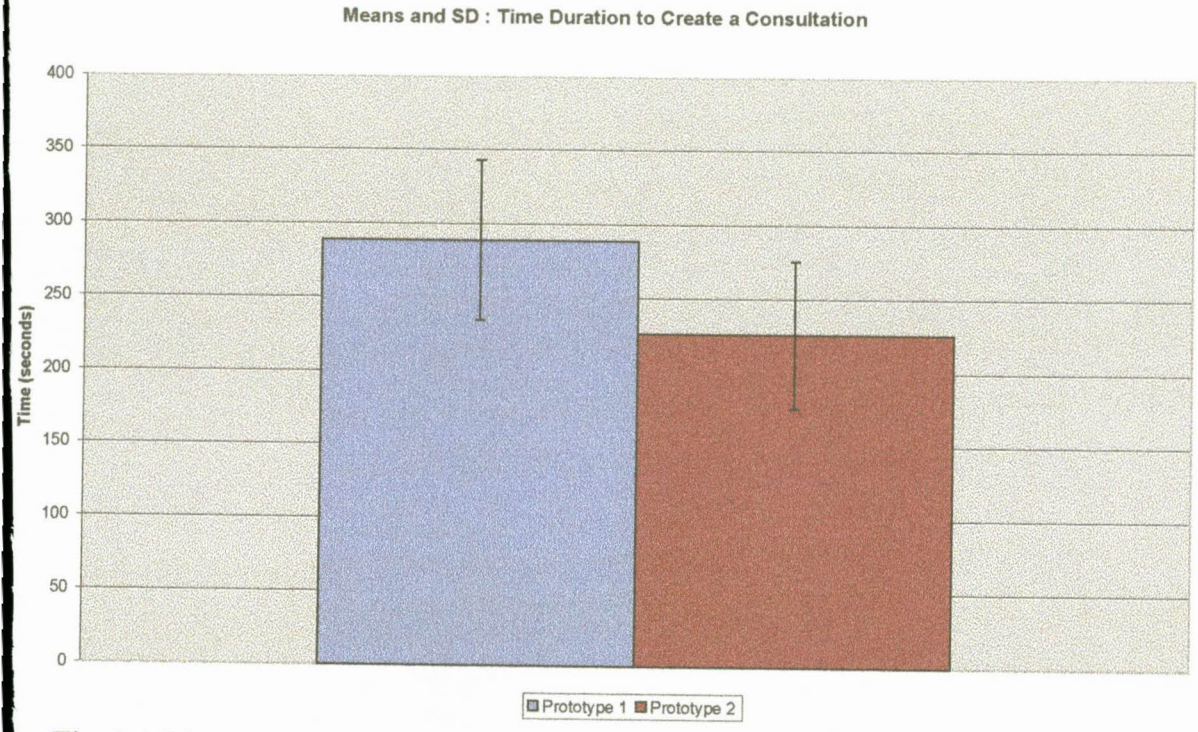


Fig. 9.1 Means and SD : Time duration to create a consultation

Columns (1) and (2) in the table show the duration to create a consultation, using the first and second prototypes respectively. As the duration times were the result of multiple presentations, it was assumed that they were normally distributed. This assumption might be identified as a limitation regarding this analysis. When considering the results of some of the other measured criteria (presented later on in this chapter), a normal distribution does not seem evident in all of them. For the purpose of this evaluation, however, it was decided that the assumption would not have a meaningful influence on the accuracy of the results.

The main independent variable, namely the prototype version, is two-valued, suggesting that a simple difference of means with Student's *t* test could be used. The within-groups design suggested that another independent variable, namely the subject, should also be

taken into consideration. The existence of more than one discrete independent variable implied the use of analysis of variance (ANOVA). A simplified version of ANOVA was considered adequate.

Columns (1) and (2) in Table 9.5 showed a wide variance among the individuals' consultation times. The wide variation emphasized the importance of the within-groups design. To see how this affected the results, an analysis was first done ignoring the fact that each subject performed using both prototypes. The mean and standard deviation (S.D.) for each prototype is presented at the bottoms of columns (1) and (2). These means could be compared using the Student's *t* test. The difference between the means is 63 seconds, but the *standard error of the difference* (S.E.D), is:

$$\sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}} = 23$$

S.E.D., therefore, is the measure of the expected variability of the difference between the means. Testing the ratio 62/23 against the Student's *t* distribution indeed shows that this is not significant. Glancing down the table, however, shows that in every case the duration of a consultation performed using the first prototype was longer than using the second prototype. This implies that the data supported the claim that the second prototype allows for faster creation of consultations (which indicates that the second prototype adheres better to the task conformance usability property), but that the wide variation between individuals has hidden the effect.

A special case of ANOVA exposed the difference. Column (3) in Table 9.5 shows the average of the consultation duration, using both prototypes, for each subject. This subject mean is then subtracted from the data for each prototype, yielding columns (4) and (5). These columns show the effect of the two prototypes *once the differences between subjects have been removed.* The two columns are actually redundant as they always add up to zero. They show that for all ten the subjects, creating a consultation using the second prototype was faster than using the first.

In conducting a *t* test, either column (4) or (5) could be used. Referring again to Table 9.5, the column average of 31 is much greater than the standard error (S.E.) $\sigma_4/\sqrt{N_4}$ = 5.41. The ratio (mean/S.E.) of 5.79 (bottom right on table) was compared to the Student's *t* table using nine degrees of freedom (10 values minus 1 for the mean). The ratio was indeed far greater than the 1% level on the *t* table, namely 3.250. This indicated that the chance of getting the results by chance was less than 1 in 100. The null hypothesis that there is no difference between the two prototypes' adherence to the task conformance usability property, could, therefore, be rejected.

A further test that could be done involves a check to see if there had been any significant transfer effect between the first and second prototype for each subject. Glancing at the different tables, the second prototype generally performed much better than the first and this difference is visible despite the order in which the prototypes were presented to the subjects. Therefore the author made the conclusion that the transfer of learning did not have a significant effect on the empirical test results. This also leads to the conclusion that the second prototype adheres better to the task conformance usability property than the first prototype.

The data for the remainder of the qualitative tests is presented in Appendix N. Appendix N also contains graphical representations of the data. When studying these graphs, it becomes evident that the data is not normally distributed – it is quite skew. It was, therefore, decided to apply a nonparametric test. A sign test was deemed to be appropriate, the reason being that this test is applicable to the case of two related samples when the experimenter wishes to establish that two conditions are different. Furthermore, the only assumption underlying this test is that the variable under consideration has a continuous distribution. The test does not make any assumptions about the form of the distribution of differences [Siegel 1956].

In what will follow the remainder of the quantitative test results (sign test results) will be presented, first in a summarised tabular format, to be followed by a brief discussion. The tables will show the number of subjects (N), the number of matched pairs (a pair

consisting of the two prototypes) that were equal (Equal), the number of pluses (a case where the second prototype performed better than the first) (+), the number of minuses (a case where the first prototype performed better than the second) (-), and the p-value (one-tailed). The region of rejection for α is 0.05.

Learnability

- **Predictability**

Qualitative evaluation

As was the case with the first prototype, the user can predict, for example, the result of pressing the buttons on the screens, of double-clicking on a grid or of using the Tab-key on a form. The provision for hints is also very useful. Generally speaking, therefore, the second prototype conforms to the predictability principle.

Quantitative evaluation

In order to test the prototype's conformance to the principle of predictability, two criteria were measured, namely:

- Number of times that the user asked for assistance

	NUMBER OF ASSISTANCE REQUESTS				
	N	Equal	+	-	p
Difference between subjects	10	4	6	0	0.016

Table 9.6 Summary of the sign test results determining the number of times that the users asked for assistance while using the first and second prototypes.

The p-value is in the region of rejection, therefore there was a significant difference between the two prototypes when the number of times that the users asked for assistance was considered.

- Number of times that the user expressed frustration.

	Number of frustrations				
	N	Equal	+	-	p
Difference between subjects	10	5	5	0	0.031

Table 9.7 Summary of the sign test results determining the number of times that the users expressed frustration while using the first and second prototypes.

The p-value is in the region of rejection, therefore there was a significant difference between the two prototypes when the number of times that the users expressed frustration was considered.

Therefore, according to these two criteria, there is a significant difference in the ways that the two prototypes support the predictability principle – the second prototype supports the principle better than the first.

- **Synthesizability**

Qualitative evaluation

The first prototype supported the property of synthesizability quite well, as does the second prototype. The messages appearing in the status bar after record storage, updates and deletes, indicate to the user that changes have taken place in the internal state of the system.

Grids are immediately updated after changes in the internal system state have taken place. The same examples used for the first prototype evaluation may be used to illustrate this point, namely the grid update after a new consultation has been created and after a new patient record has been created. Immediate grid updates after adding, deleting or changing previous illnesses, operations, injuries, etc. may also be used as examples. Therefore, it is concluded that the second prototype supports the principle of synthesizability.

Quantitative evaluation

In order to test the prototype's conformance to the principle of synthesizability, one criterion was measured, namely:

- Number of times that a message appears in the status bar.

	Number of status bar messages				
	N	Equal	+	-	p
Difference between subjects	10	1	6	3	0.254

Table 9.8 Summary of the sign test results determining the number of times that a message appeared in the status bar while using the first and second prototypes.

The p-value falls outside the region of rejection, therefore there was no significant difference between the two prototypes when the number of times that a message appeared in the status bar was considered. Therefore, according to this criterion, there is no significant difference in the ways that the two prototypes support the synthesizability principle.

- **Familiarity**

Qualitative evaluation

The re-implementation of the SOAP model as the structure for creating a medical note again provides a familiar environment for the physician. Additionally, the use of the tab-method whereby the EPR resembles a manual paper patient record enhances familiarity. The physician using the system for the first time finds it easier to relate to the electronic version if it appears familiar to what they are used to.

Quantitative evaluation

In order to test the prototype's conformance to the principle of familiarity, three criteria were measured, namely:

- Number of times that the user asked for assistance

According to Table 9.6 the p-value was in the region of rejection, therefore there was a significant difference between the two prototypes when the number of times that the users asked for assistance was considered.

- Time spent on errors

	Time (s)				
	N	Equal	+	-	p
Difference between subjects	10	1	8	1	0.020

Table 9.9 Summary of the sign test results determining the time spent on errors while using the first and second prototypes.

The p-value is in the region of rejection, therefore there was a significant difference between the two prototypes when the time spent on errors was considered. More time were spent on errors in the first prototype than in the second.

- Number of errors

	Number of errors				
	N	Equal	+	-	p
Difference between subjects	10	3	7	0	0.008

Table 9.10 Summary of the sign test results determining the number of errors while using the first and second prototypes.

The p-value is in the region of rejection, therefore there was a significant difference between the two prototypes when the number of errors was considered.

Therefore, according to these three criterion, there is a significant difference in the ways that the two prototypes support the synthesizability principle - the second prototype support the principle better than the first.

- **Generalizability**

Qualitative evaluation

The "Windows-feel" surrounding the first prototype was enhanced by the use of the tab-method in the second prototype. This is a very popular user interface component often found in Windows applications. Users who are accustomed to the Windows environment should, therefore, find it relatively easy to adapt to the second prototype. The aspects identified as lacking in the first EPR prototype when compared to general Windows applications, however, still apply, namely cut, copy, and paste functionality, as well as formalised undo/redo functions.

In the evaluation of the first prototype it has been mentioned that the use of the TAB key to move from field to field in stead of the ENTER key might cause usability problems. The development environment used to develop the prototypes supports the use of the TAB key for this purpose. It was, therefore, decided to stick to the TAB key for the time being. In future the user might be given a choice as to the key preferred.

From the above it is, therefore, concluded that the second prototype partially supports the generalizability usability principle.

Quantitative evaluation

In order to test the prototype's conformance to the principle of generalizability, one criterion was measured, namely:

- Number of times where *ENTER* was pressed in stead of *TAB*.

	Number of ENTER button-presses				
	N	Equal	+	-	p
Difference between subjects	10	6	3	1	0.316

Table 9.11 Summary of the sign test results determining the number of times where ENTER was pressed in stead of TAB while using the first and second prototypes.

The p-value falls outside the region of rejection, therefore there was no significant difference between the two prototypes when the number of times where *ENTER* in stead of *TAB* was pressed was considered. Therefore, according to this criterion, there is no significant difference in the ways that the two prototypes support the generalizability principle.

- **Consistency**

Qualitative evaluation

As a result of the vast scope covered by the term *consistency*, it was already decided during the evaluation of the first prototype that the prototypes' conformance to consistency would be evaluated in a qualitative manner.

The second prototype is much more consistent in many aspects than the first prototype. The reader is referred to section 9.4 where the second prototype's appliance to consistency was discussed extensively during the heuristic evaluation process.

The additional consistency angles mentioned in section 6.3.3.2, namely semantic, syntactic, and physical consistencies, are also supported in the second prototype. The same examples used to illustrate this point for semantic and physical consistency in the first prototype also apply here. The problems that were identified with syntactic consistency in the first prototype concerning the use of

colour in grids and the inconsistent use of bitbuttons, have been solved in the second prototype (as can be seen in section 9.4).

The second prototype, therefore, supports the consistency usability principle.

- **Interaction metaphors**

  Qualitative evaluation

  Re-applying the SOAP model as a framework for entering a consultation on the computer in the second prototype may again be viewed as an interaction metaphor. Apart from that, the introduction of the tab-method in the second prototype depicts the manual EPR (current real-world situation) in the interface. Interaction metaphors are, therefore, supported in the second prototype.

- **Visual clarity**

  Qualitative evaluation

  The Family and Patient screens in the second prototype were re-arranged in an attempt to reduce the perception of cluttered screens. Despite the addition of a residential address and email address on the Family screen, the screen seems more visually attractive as a result of the re-arrangements. On both the Family and Patient screens space was saved by hiding the remark memorandum fields. This served an additional purpose: the physicians requested the remarks to be hidden to prevent patients from seeing what had been entered in the field (the remarks are often meant for "the doctor's eyes only"!). On the Patient screen patient information was grouped vertically in stead of horizontally (as was the case in the first prototype).

  The implementation of the tabs indirectly contributed to space savings on screens. With the tabs visible at the top of the screen, the navigational buttons on the screens were redundant and could be removed, thus saving screen space.

  In order to enhance the visual clarity of the second prototype, the information contained on the History and Examination screens were also re-arranged in

comparison to the first prototype. The nature of the consultation and the first/follow-up fields were moved from the Examination to the History screen. As this information is known before the consultation starts, it is more meaningful to present it at the beginning of the consultation. Following the advice of physicians, the "differential/final diagnosis" field was moved to the Assessment screen. The general appearance part of the system was added to the Examination screen (in the first prototype it was contained on a separate screen), as ample space was left after the screen re-arrangement.

It was mentioned before that the displaying of a previous consultation over three screens sabotaged the clarity of the first prototype design. In an attempt to rectify the matter, all the information pertaining to a previous consultation is now grouped together as a meaningful unit on a preview-printing screen in the second prototype.

The second prototype is, therefore, perceived as being visually clear.

- **User guidance and support**

  Qualitative evaluation

  The reader is referred to "Help and Documentation" as discussed in section 9.4. The conclusions drawn from the heuristic evaluation regarding user guidance and support in the second prototype may be applied to the usability testing as well, namely that the second prototype partially complies with this usability principle.

- **Enjoyability**

  Qualitative evaluation

  Without exception, the ten subjects participating in the quantitative evaluation indicated during post-task walkthroughs that they enjoyed using the second prototype more that the first. The aspects specifically mentioned were the simplicity of the system, the use of the tabs to create a familiar environment and

to facilitate fast movement among screens and the fact that the user felt in control of the system.

Therefore it is concluded that the second prototype supports the enjoyability usability principle.

- **Conceptual (mental) models**

  Qualitative evaluation

  It has been mentioned before that the same procedures were followed in conducting observational evaluations with the two prototypes. Therefore, the subjects participating in the evaluation of the second prototype were handed a set of installation diskettes, installation instructions and an example of a consultation. As a general rule no demonstration of the prototype was given. The subjects had to explore the system on their own. As was the case with the first prototype no phone calls or queries were made to the designer that could indicate that any of the ten subjects experienced problems when they started using the second prototype and performed the given tasks.

  The same could be said of the physicians participating in the query technique evaluation of the second prototype. Ten of the twenty physicians had never had any exposure to the second prototype when they were handed the set of installation disks. They, also, did not appear to have any major problems getting started and testing the system. These facts are seen as indications that the subjects were able to form a clear cognitive model of what the second prototype does and how it does it.

- **Flexibility**
  - **Dialogue initiative (pre-emption)**

    Qualitative evaluation

    Where the first prototype was perceived to be more system pre-emptive, the second prototype is perceived to be more user pre-emptive. The introduction of

tab sheets ensured that the user has the freedom to move around the screens in the order of his/her personal preference. When the user is satisfied that the consultation is entered adequately, the user initiates the saving of the consultation by pressing the "Confirm this consultation"-button. In a way the user is still slightly inhibited, as the above-mentioned button only appears on the Plan screen. The user, therefore, has to navigate to the Plan screen to save a consultation, even though he/she had no other reason for navigating to the screen.

Despite the general feel of user pre-emption surrounding the second prototype, some system pre-emption was deliberately introduced. In addition to the modal dialogue boxes requesting confirmation for delete actions, modal dialogue boxes were introduced to confirm the user's intentions of saving a consultation as well as the intention of leaving the system entirely. The first prototype did not cater for these safety measures.

The second prototype therefore generally complies with the flexibility usability principle.

Quantitative evaluation

In order to test the prototype's conformance to the principle of dialogue initiative, one criterion was measured, namely:

- Number of times that the user is prohibited from following a step/path.

	Number of prohibitions				
	N	Equal	+	-	p
Difference between subjects	10	2	8	0	0.004

Table 9.12 Summary of the sign test results determining the number of times that the users were prohibited from following a step/path while using the first and second prototypes.

The p-value is in the region of rejection, therefore there was a significant difference between the two prototypes when the number of times that the users

were prohibited from following a step/path was considered. The first prototype is more prohibitive than the second prototype. Therefore, according to this criterion, there is a significant difference in the ways that the two prototypes support the dialogue initiative principle – the second prototype supports the principle, specifically user pre-emption, better than the first.

- **Multi-threading**

Qualitative evaluation

As was mentioned with regard to the first prototype, a windowing application naturally supports a multi-threaded dialogue. While using the second EPR prototype, the user may leave the system as is and first read his/her electronic mail messages in another application. While busy entering a consultation on the second prototype system, the physician may invoke the Query option that was included in the second prototype to view the information pertaining to another, entirely different patient. After the query has been conducted, he/she may return to the patient consultation that was in progress and continue where he/she left off. The second prototype, therefore, supports more than one task at a time, called multi-threading.

When considering the aspect of multi-modality (section 6.3.3.2), what was said regarding the first prototype's conformance to this aspect also applies here.

Quantitative evaluation

In order to test the prototype's conformance to the principle of multi-threading, one criterion was measured, namely:

- Number of times where keyboard-use was attempted in vain.

	Number of keyboard attempts				
	N	Equal	+	-	p
Difference between subjects	10	6	3	1	0.316

Table 9.13 Summary of the sign test results determining the number of times where keyboard-use was attempted in vain while using the first and second prototypes.

The p-value falls outside the region of rejection, therefore there was no significant difference between the two prototypes when the number of times where keyboard-use was attempted in vain was considered. Therefore, according to this criterion, there is no significant difference in the ways that the two prototypes support the multi-threading principle.

- **Task migratability**

Qualitative evaluation

A few examples of complying with task migratability may be found when considering the second prototype. Two of the examples used to illustrate the point in the first prototype evaluation, may be used here as well. These include the system responding with a list of all possible families that meet the requirements as specified by the user when a family is searched for on surname/part of surname. The system does not make the most likely choice – this choice is left to the user. The second example involves that confirmation is expected when an item is deleted. The second prototype provides the user with two more confirmations, namely when the consultation is saved and when the exit-button is pressed.

Another example of task migratability was introduced in the second prototype. This involves the consultation date and time. As the user opens the History screen to commence entering a consultation, the current date and time is presented in two fields. The user may, however, change the date and time (if so required) until the main complaint is finalised. The reason for this is that the physician might only enter the information pertaining to a house call made the previous evening, early

the next morning. The date and time must, therefore, reflect the date and time of the visit, and not of the creation of the EPR.

The second prototype, therefore, supports task migratability more than the first prototype did.

Quantitative evaluation

In order to test the prototype's conformance to the principle of task migratability, one criterion was measured, namely:

- Number of times where the system asked for confirmation.

	Number of confirmations				
	N	Equal	+	-	p
Difference between subjects	10	0	10	0	0.001

Table 9.14 Summary of the sign test results determining the number of times where the system asked for confirmation while using the first and second prototypes.

The p-value is in the region of rejection, therefore there was a significant difference between the two prototypes when the number of times the system asked for confirmation was considered. The user is more frequently asked to confirm his/her actions while using the second prototype, than while using the first. Therefore, according to this criterion, there is a significant difference in the ways that the two prototypes support the task migratability principle – the second prototype supports the principle better than the first.

- **Substitutivity**

Qualitative evaluation

The second prototype does just as well as the first prototype regarding the substitutivity principle when considering the principle of *equal opportunity*. The distinction between input and output is blurred where the user double-clicks on an

item (user input), displayed by the system in a grid (system output), to obtain more detailed information about it.

The introduction of more defaults in the second prototype may also be considered as equal opportunity. This issue will, however, be discussed when the second prototype is evaluated for its *observability*.

Generally the second prototype supports the substitutivity usability principle.

Quantitative evaluation

In order to test the prototype's conformance to the principle of substitutivity, one criterion was measured, namely:

- Number of times where output on tables was used for input

	Number of output-input uses				
	N	Equal	+	-	p
Difference between subjects	10	3	1	6	0.992

Table 9.15 Summary of the sign test results determining the number of times where output on tables was used for input while using the first and second prototypes.

The p-value falls outside the region of rejection, therefore there was no significant difference between the two prototypes when the number of times where output on tables were used for input was considered. Therefore, according to this criterion, there is no significant difference in the ways that the two prototypes support the substitutivity principle.

- **Customizability**

Qualitative evaluation

The second prototype (like the first prototype) does not meet the adaptivity (system-initiated modification) requirement. The user interface is, therefore, not

automatically customized by the system, based on user expertise or observed repetition of certain task sequences.

Where the first prototype supported adaptability in a very limited way, the second prototype went much further. A "Maintain" option is presented to the user and is constantly available while the system is running. On the Maintain screen the user may customize the lists that are presented in combo boxes on other screens throughout the prototype. Examples include titles, types of consultations, marital status, languages, and different types of investigations. The Maintain option can easily be expanded to accommodate other aspects that physicians would like to customize.

Bearing the above-mentioned adaptivity requirement in mind, the second prototype, however, only partially complies with the customizability usability principle.

Quantitative evaluation

In order to test the prototype's conformance to the principle of customizability, one criterion was measured, namely:

- Number of times where the user would want options / different values.

	Number of desired different options				
	N	Equal	+	-	p
Difference between subjects	10	5	3	2	0.500

Table 9.16 Summary of the sign test results determining the number of times where the user would want options / different values while using the first and second prototypes.

The p-value falls outside the region of rejection, therefore there was no significant difference between the two prototypes when the number of times where the user would want options/different values was considered. Therefore, according to this

criterion, there is no significant difference in the ways that the two prototypes support the customizability principle.

- **Control**

  Qualitative evaluation

  Where the first prototype does not provide the user with a feeling of being in control – the system leads the user into predefined paths – the tab sheets in the second prototype do just that. The user has the freedom to move around among screens in any order. The control usability principle is, therefore, supported in the second prototype.

- **Robustness**
  - **Observability**

    Qualitative evaluation

    In Chapter 6 it was stated that observability could be discussed in terms of four other principles, namely browsability, defaults, reachability, and persistence.

    The second prototype provides a "neater" way to conform to the *browsability* principle. This is done by providing the user with a means to view a previous consultation on one screen. The use of grids (used in the same manner as in the first prototype) on the previous history screens to list all the user's previous illnesses, operations, injuries, examinations, medication or his/her allergies, also allows the user to browse.

    Defaults can be categorised into static and dynamic defaults (refer to section 6.3.2.1). Where only one example of a static default could be found in the first prototype, six examples could be identified in the second prototype. These are the display of the current date and time, the attending physician, the nature of the consultation, first/follow-up consultation, the problem date on the assessment screen, and the prescription date on the previous medication screen. Dynamic default examples include the transfer of the residential address between the

Family and Patient screens, the transfer of the medical aid information between these two screens and the transfer of the title, name, surname and initials of a patient from the Family screen if he/she is the head of the family. The dynamic display of a patient's date of birth and age after the identification number has been entered is another example.

Reachability refers to the possibility of navigation through the observable system state. As this principle is closely related to recoverability, it will be addressed later in this section.

Persistence refers to the duration of the effect of a communication act and the ability of the user to make use of that effect. As was mentioned before, the messages appearing in the status bar comply with the persistence principle.

The second prototype, therefore, supports observability fairly well.

Quantitative evaluation

In order to test the prototype's conformance to the principle of observability, two criteria were measured, namely:

- Number of static default values on the screen

	Number of static defaults				
	N	Equal	+	-	p
Difference between subjects	10	0	10	0	0.001

Table 9.17 Summary of the sign test results determining the number of static default values on the screen while using the first and second prototypes.

The p-value is in the region of rejection, therefore there was a significant difference between the two prototypes when the number of static default values on the screen was considered. The second prototype contained much more static default values than the first.

- Number of dynamic default values on the screen

	Number of dynamic defaults				
	N	Equal	+	-	p
Difference between subjects	10	0	10	0	0.001

Table 9.18 Summary of the sign test results determining the number of dynamic default values on the screen while using the first and second prototypes.

The p-value is in the region of rejection, therefore there was a significant difference between the two prototypes when the number of dynamic default values on the screen was considered. The second prototype contained more static default values than the first.

According to these two criteria, therefore, there is a significant difference in the ways that the two prototypes support the observability principle.

- **Recoverability**

Qualitative evaluation

The ways in which the first prototype attempted to reduce the likelihood of errors (part of recoverability) are expanded in the second prototype. When trying to access the system, a list of all the physicians/personnel who have the right to use the system in a specific private practice, is presented to the user. When selecting a physician/person on this list, the password still needs to be typed in to gain access.

Validation of new account numbers and patient identification numbers are again provided, as well as the presentation of choices to users in combo boxes where possible. In addition to confirmation for deletion, confirmation for saving and leaving the system is expected.

The *forward recovery* processes provided for in the second prototype, are much more streamlined than those provided for in the first prototype. The tab sheets allow for easy retracing of one's steps when an error needs to be rectified. Clear and delete-buttons are also provided for in the second prototype to serve as error recovery methods. Like its predecessor, the second prototype does not support undo and redo functions, and therefore does not support *backward recovery* methods.

In Chapter 6 it was stated that the principle of *commensurate effort* may be applied to the fact that a user is not allowed (for medico-legal purposes) to change a consultation once it is stored. Although this is still true for the second prototype, provision was, however, made to add a memorandum to a specific consultation by means of the "Modify" screen.

The second prototype, therefore, partially supports recoverability.

Quantitative evaluation

In order to test the prototype's conformance to the principle of recoverability, two criteria were measured, namely:

- Time duration to make a correction

	Time (s)				
	N	Equal	+	-	p
Difference between subjects	10	1	8	1	0.020

Table 9.19 Summary of the sign test results determining the time duration to make a correction while using the first and second prototypes.

The p-value is in the region of rejection, therefore there was a significant difference between the two prototypes when the time duration to make a correction was considered. It was quicker to make a correction using the second prototype than using the first.

- Number of steps necessary to make a correction

	Number of steps				
	N	Equal	+	-	p
Difference between subjects	10	6	3	1	0.316

Table 9.20 Summary of the sign test results determining the number of steps necessary to make a correction while using the first and second prototypes.

The p-value falls outside the region of rejection, therefore there was no significant difference between the two prototypes when the number of steps necessary to make a correction was considered.

The results according to these two criteria vary. The reader is, therefore, referred to section 9.5.3 where these results will be discussed.

- **Responsiveness**

Qualitative evaluation

The feedback received from users regarding the response time of the second prototype was very positive. As was mentioned with respect to the first prototype, it must be born in mind that the increasing number of patients in the database might have an effect on response time in future and therefore should be carefully monitored. In the mean time, however, it is concluded that the second prototype supports responsiveness very well.

- **WYSIWYG**

Qualitative evaluation

In the first prototype the user was presented with three screens when viewing a previous consultation/clinical note. What the user saw on the computer screen, could therefore not be similar to what he would see on paper – the first prototype, therefore, did not conform to the WYSIWYG principle. This shortcoming was addressed in the second prototype. When viewing a previous consultation the user is presented with a preview of what the clinical note would look like on paper.

The three separate screens of the first prototype are thereby replaced with a single WYSIWYG screen. The second prototype therefore supports the WYSIWYG principle.

- **Task conformance** – A task analysis was performed to ensure that the first prototype serviced and supported the task of creating a patient consultation, as well as the way the user understood it. The same procedures that were followed during the task analysis for the first prototype (as described in Chapter 6) were also followed for the second prototype. Before describing the task analysis process, the results of the quantitative evaluation for task conformance will be given.

Quantitative evaluation

In order to test the prototype's conformance to the principle of task conformance, one criterion was measured, namely:

- Time duration to create a consultation.

The reader is referred to Table 9.5 where the results of this criterion were presented in detail as an example. It was then concluded that the mean values differed significantly between the two prototypes when the time duration to create a consultation was considered. It was quicker to create a consultation using the second prototype than using the first. Therefore, according to this criterion, there is a significant difference in the ways that the two prototypes support the task conformance principle – the second prototype supports the principle better than the first.

In what follows the results of this second prototype task analysis will briefly be presented. (The reader is referred to Chapter 6 and the literature referred to for more detail). An attempt will also be made to highlight the differences in the task analysis outcomes with regard to the two prototypes.

Task analysis

This section on the task analysis that was performed on the second prototype will be presented in the same way as the first prototype task analysis (refer to Chapter 6). The problem area, task problem statement and task observation, and data collection sections do not differ from those in Chapter 6. The rest of the second prototype task analysis will be discussed under the following headings:

- Task activity list (AL) and prose description
- Selection of specific objects and specific actions
- Task descriptive hierarchy
- KRG sentences
- KRG sequence analysis
- Discussion of task analysis results.

• Task activity list (AL) and prose description

- The last refined version of the task AL for the second prototype is presented in Table 9.21 in a similar manner as for the first prototype in Table 6.4.

Line	Screen	Prose description	Specific Object() and Action[]
1		Title: EPR system consultation creation	
2			
3	Family	Computer displays families page	(computer) [display1] (page-family)
4	Family	Computer prompts for search button press	(computer) [prompt1] (button-search)
5	Family	Computer prompts for creating a new family via new family button	(computer) [prompt2] (page-family) (button-newfamily)
6	Family	Computer prompts for creating a new patient via new patient button	(computer) [prompt3] (page-patient) (button-newpatient1)
7	Family	Computer prompts for clear button press	(computer) [prompt4] (button-clear1)
8	Family	Computer displays search a family dialog box	(computer) [display2] (dialogbox-search)
9	Family	Computer prompts for account number to search on	(computer) [prompt5] (consultation-accountnumber)
10	Family	Computer prompts for surname to search on	(computer) [prompt6] (consultation-surname)
11	Family	Computer prompts for dialog box buttons press	(computer) [prompt7] (button-dialogbox-ok1) (button-dialogbox-cancel2)
12	Family	Computer prompts for dependant on grid	(computer) [prompt8] (grid-consultation-dependant)
13	Family	Computer prompts for navigation to other pages via tabs	(computer) [prompt9] (page-others) (tab)
14	Family	Computer prompts for exit button press	(computer) [prompt10] (button-exit)
15	Family	User presses search button	(user) [press1] (button-search)

16	Family	User enters account number	(user) [enter1] (consultation-accountnumber)
17	Family	User presses dialog box ok button	(user) [press2] (button-dialogbox-ok1)
18	Family	User double-clicks on dependant grid	(user) [dbl-click] (grid-consultation-dependant)
19	Patient	Computer displays patients page	(computer) [display3] (page-patient)
20	Patient	Computer prompts for navigation to other pages via tabs	(computer) [prompt11] (page-others) (tab)
21	Patient	Computer prompts for creating a new patient via new patient button	(computer) [prompt12] (page-patient) (button) (newpatient2)
22	Patient	Computer prompts for cancel button	(computer) [prompt13] (button-cancel)
23	Patient	Computer prompts for previous appointments on grid	(computer) [prompt] (grid-consultation-previous)
24	Patient	Computer prompts for exit button press	(computer) [prompt14] (button-exit)
25	Patient	User presses history tab	(user) [press3] (tab-history)
26	History	Computer displays history page	(computer) [display5] (page-history)
27	History	Computer prompts for navigation to other pages via tabs	(computer) [prompt15] (page-others) (tab)
28	History	Computer prompts for clear button press	(computer) [prompt16] (button-clear2)
29	History	Computer displays current date and time	(computer) [display6] (consultation-datetime)
30	History	Computer displays physician	(computer) [display7] (consultation-physician)
31	History	Computer prompts for nature of consultation on drop-down combo box	(computer) [prompt17] (dropdowncombobox-nature)
32	History	Computer prompts for first/follow-up on drop-down combo box	(computer) [prompt18] (dropdowncombobox-first)
33	History	Computer prompts for main complaint	(computer) [prompt19] (consultation-maincomplaint)
34	History	Computer prompts for navigation to previous illness page via illness button	(computer) [prompt20] (page-previllness) (button-illness)
35	History	Computer prompts for navigation to previous operations page via operations button	(computer) [prompt21] (page-prevoperations) (button-operations)
36	History	Computer prompts for navigation to previous injuries page via injuries button	(computer) [prompt22] (page-previnjuries) (button-injuries)
37	History	Computer prompts for navigation to previous investigations page via investigations button	(computer) [prompt23] (page-previnvestigations) (button-investigations)
38	History	Computer prompts for navigation to previous medication page via medication button	(computer) [prompt24] (page-prevmedication) (button-medication)
39	History	Computer prompts for navigation to allergies page via allergies button	(computer) [prompt25] (page-allergies) (button-allergies)
40	History	Computer prompts for family history	(computer) [prompt26] (consultation-history)
41	History	Computer prompts for general profile	(computer) [prompt27] (consultation-genprofile)
42	History	Computer prompts for navigation to systemic history page via systemic inquiry button	(computer) [prompt28] (page-systemichistory) (button-systemichistory)
43	History	Computer prompts for exit button press	(computer) [prompt29] (button-exit)
44	History	User enters main complaint	(user) [enter2] (consultation-maincomplaint)
45	History	User presses examination tab	(user) [press4] (tab-examination)
46	Examination	Computer displays examination page	(computer) [display8] (page-examination)
47	Examination	Computer prompts for navigation to other pages via tabs	(computer) [prompt30] (page-others) (tab)
48	Examination	Computer prompts for clear button press	(computer) [prompt31] (button-clear3)
49	Examination	Computer prompts for length	(computer) [prompt32] (consultation-length)
50	Examination	Computer prompts for weight	(computer) [prompt33] (consultation-weight)
51	Examination	Computer displays body/mass index	(computer) [display9] (consultation-bodymassindex)
52	Examination	Computer prompts for abdominal circumference	(computer) [prompt34] (consultation-abdominalcircumference)
53	Examination	Computer prompts for temperature	(computer) [prompt35] (consultation-temperature)
54	Examination	Computer prompts for pulse rate	(computer) [prompt36] (consultation-pulserate)
55	Examination	Computer prompts for respiration rate	(computer) [prompt37] (consultation-respiratoryrate)
56	Examination	Computer prompts for blood pressure	(computer) [prompt38] (consultation-bloodpressure)
57	Examination	Computer prompts for general appearance	(computer) [prompt39] (consultation-

		state	gappearstate)
58	Examination	Computer prompts for navigation to systemic investigation page via systemic investigation button	(computer) [prompt40] (page-systemicinvestigation) (button-systemicinvestigation)
59	Examination	Computer prompts for side room investigation page via side room investigation button	(computer) [prompt41] (page-sideroominvestigation) (button-sideroominvestigation)
60	Examination	Computer prompts for exit button press	(computer) [prompt42] (button-exit)
61	Examination	User enters length	(user) [enter3] (consultation-length)
62	Examination	User enters weight	(user) [enter4] (consultation-weight)
63	Examination	User selects general appearance state	(user) [select1] (consultation-gappearstate)
64	Examination	User presses side room investigation button	(user) [press5] (button-sideroominvestigation)
65	Side room	Computer displays side room investigation page	(computer) [display10] (page-sideroominvestigation)
66	Side room	Computer prompts for clear button press	(computer) [prompt43] (button-clear4)
67	Side room	Computer prompts for delete button press	(computer) [prompt44] (button-delete)
68	Side room	Computer prompts for ok button press	(computer) [prompt45] (button-ok1)
69	Side room	Computer prompts for close button press	(computer) [prompt46] (button-close)
70	Side room	Computer prompts for investigation on drop-down combo box	(computer) [prompt47] (dropdowncombobox-investigation)
71	Side room	Computer prompts for results	(computer) [prompt48] (consultation-results)
72	Side room	Computer prompts for notes	(computer) [prompt49] (consultation-notes)
73	Side room	Computer prompts for side room investigations in grid	(computer) [prompt50] (grid-sideroominvestigations)
74	Side room	Computer prompts for new type of investigation	(computer) [prompt51] (consultation-newinvestigation)
75	Side room	Computer prompts for add new investigation button press	(computer) [prompt52] (button-newinvestigation)
76	Side room	User opens investigations drop-down combo box	(user) [open] (dropdowncombobox-investigations)
77	Side room	User selects investigations from drop-down combo box	(user) [select2] (dropdowncombobox-investigation) (consultation-investigation)
78	Side room	User presses ok button	(user) [press6] (button-ok1)
79	Side room	User presses close button	(user) [press7] (button-close)
80	Examination	Computer displays examination page	(computer) [display11] (page-examination)
81	Examination	User presses assessment tab	(user) [press8] (tab-assessment)
82	Assessment	Computer displays assessment page	(computer) [display12] (page-assessment)
83	Assessment	Computer prompts for navigation to other pages via tabs	(computer) [prompt53] (page-others) (tab)
84	Assessment	Computer prompts for clear button press	(computer) [prompts54] (button-clear5)
85	Assessment	Computer prompts for ok button press	(computer) [prompt55] (button-ok2)
86	Assessment	Computer prompts for problem	(computer) [prompt56] (consultation-problem)
87	Assessment	Computer prompts for problem date on drop-down combo box	(computer) [prompt57] (dropdowncombobox-problemdate)
88	Assessment	Computer prompts for outcome	(computer) [prompt58] (problemoutcome)
89	Assessment	Computer prompts for outcome date on drop-down combo box	(computer) [prompt59] (dropdowncombobox-outcomedate)
90	Assessment	Computer prompts for problems in grid	(computer) [prompt60] (grid-problems)
91	Assessment	Computer prompts for problem viewing options	(computer) [prompt61] (radiobutton-problemview)
92	Assessment	Computer prompts for differential/final diagnosis	(computer) [prompt62] (consultation-diagnosis)
93	Assessment	Computer prompts for exit button press	(computer) [prompt63] (button-exit)
94	Assessment	User enters problem	(user) [enter5](consultation-problem1)
95	Assessment	User presses ok button	(user) [press9] (button-ok2)
96	Assessment	User enters problem	(user) [enter6] (consultation-problem2)
97	Assessment	User presses ok button	(user) [press10] (button-ok2)
98	Assessment	User enters differential/final diagnosis	(user) [enter7] (consultation-diagnosis)
99	Assessment	User presses plan tab	(user) [press11] (tab-plan)
100	Plan	Computer displays plan page	(computer) [display13] (page-plan)
101	Plan	Computer prompts for navigation to other pages via tabs	(computer) [prompt64] page-others)(tab)
102	Plan	Computer prompts for clear button press	(computer) [prompt65] (button-clear6)
103	Plan	Computer prompts for confirm this consultation press	(computer) [prompt66] (button-confirm)
104	Plan	Computer prompts for possible Dx investigations in grid	(computer) [prompt67] (grid-Dxinvestigations)
105	Plan	Computer prompts for new Dx	(computer) [prompt68] (consultation-newDx)

106	Plan	Computer prompts for add new Dx button press	(computer) [prompt69] (button-addnewDx)
107	Plan	Computer prompts for selecting Dx	(computer) [prompt70] (arrow-Dx)
108	Plan	Computer prompts for navigation to previnvestigations page via to results button press	(computer) [prompt71] (page-previnvestigations) (button-toresults)
109	Plan	Computer prompts for Rx	(computer) [prompt72] (consultation-Rx)
110	Plan	Computer displays not implemented yet dialog box	(computer) [display14] (dialogbox-Rxnotimplemented)
111	Plan	Computer prompts for dialog box buttons press	(computer) [prompt73] (button-dialogbox-ok)
112	Plan	Computer prompts for Cx	(computer) [prompt74] (consultation-Cx)
113	Plan	Computer prompts for follow-up visit	(computer) [prompt75] (consultation-followupvisit)
114	Plan	Computer prompts for exit button press	(computer) [prompt76] (button-exit)
115	Plan	Computer displays confirm consultation dialog box	(computer) [display15] (dialogbox-confirmconsult)
116	Plan	Computer prompts for dialog box button press User enters Cx User presses confirm this consultation button User presses dialog box ok button	(computer) [prompt77] (button-dialogbox-ok2)(button-dialogbox-cancel2) (user) [enter8] (consultation-Cx) (user) [press12] (button-confirm) (user) [press13] (button-dialogbox-ok2)
117	Patient	Computer displays patient page	(computer) [display16] (page-patient]
118	Patient	Computer displays exit confirmation dialog box	(computer) [display17] (dialogbox-exitconfirm)
119	Patient	Computer prompts for dialog box button press	(computer) [prompt78] (button-dialogbox-ok3)(button-dialogbox-cancel3)
120	Patient	User presses exit button	(user) [press14] (button-exit)
121	Patient	User presses dialog box ok button	(user) [press15] (button-dialigbox-ok3)

Table 9.21 Activity list for the consultation task for the second EPR prototype

- Selection of specific objects and specific actions

The specific object list for the second prototype is presented in Table 9.22, and the specific activity list in Table 9.23. As was the case in Table 6.5 and Table 6.6, the raw list of all the objects and actions from the AL is listed on the left-hand side, while the refined filtered list, where all the objects and actions not relevant to the task were removed, is presented on the right.

Unfiltered specific object list	Filtered and refined specific object list	
Computer	agent-computer	page
User		family
page-family		patient
page-patient		history
page-history		assessment
page-assessment		examination
page-examination		sideroominvestigation
page-previllness		plan
page-prevoperation		dialogbox-search
page-previnjuries		dialogbox-confirmconsult
page-prevexaminations		dialogbox-exitconfirm
page-prevmedication	button	search
page-allergies		ok
page-systemichistory		close
page-systemicinvestigations		dialogbox-ok

page-sideroominvestigations		sideroominvestigations
page-plan		confirm
page-others		exit
button-search		
button-newfamily	tab	history
button-newpatient1		assessment
button-newpatient2		examination
button-clear1		plan
button-clear2		
button-clear3	grid	consultation-dependant
button-clear4		
button-clear5	agent-user consultation	consultation
button-clear6		accountnumber
button-ok1		surname
button-ok2		dependant
button-close		maincomplaint
button-exit		length
button-cancel		weight
button-delete		select-dropdowncombobox
button-illness		nature
button-operations		first
button-injuries		gappearstate
button-investigations		investigation
button-medication		problem
button-allergies		problemdate
button-systemichistory		diagnosis
button-newinvestigation		Cx
button-systemicinvestigations		
button-sideroominvestigations		
button-addnewDx		
button-toresults		
button-dialogbox-ok1		
button-dialogbox-ok2		
button-dialogbox-ok3		
button-dialogbox-cancel1		
button-dialogbox-cancel2		
button-dialogbox-cancel3		
button-confirm		
tab		
tab-history		
tab-assessment		
tab-examination		
tab-plan		
grid-consultation-dependant		
grid-consult-previous		
grid-sideroominvestigations		
grid-problems		
grid-Dxinvestigations		
consultation-accountnumber		
consultation-surname		
consultation-dependant		
consultation-maincomplaint		
consultation-history		
consultation-genprofile		
consultation-length		
consultation-weight		

consultation-bodymassindex consultation-abdominalcircumference consultation-temperature consultation-pulserate consultation-respiratoryrate consultation-bloodpressure consultation-diagnosis consultation-datetime consultation-nature consultation-first consultation-investigation consultation-results consultation-notes consultation-newinvestigation consultation-newDx consultation-Rx consultation-Cx consultation-followupvisit consultation-gappearstate consultation-problem1 consultation-problem2 consultation-problemoutcome consultation-physician dropdowncombobox-nature dropdowncombobox-first dropdowncombobox-investigation dropdowncombobox-problemdate dropdowncombobox-outcomedate radiobutton-problemview arrow-Dx dialogbox-search dialogbox-Rxnotimplemented dialogbox-confirmconsult dialogbox-exitconfirm	

Table 9.22 Specific object list for the second EPR prototype

	Unfiltered specific activity list		Filtered specific activity list	
Agent	**Activity**	**Frequency**	**Activity**	**Frequency**
Computer	prompt	78	prompt	78
	display	17	display	17
User	press	15	press	15
	enter	8	enter	8
	select	2	select	4
	open	1		
	dbl-click	1		

Table 9.23 Specific activity list for the second prototype

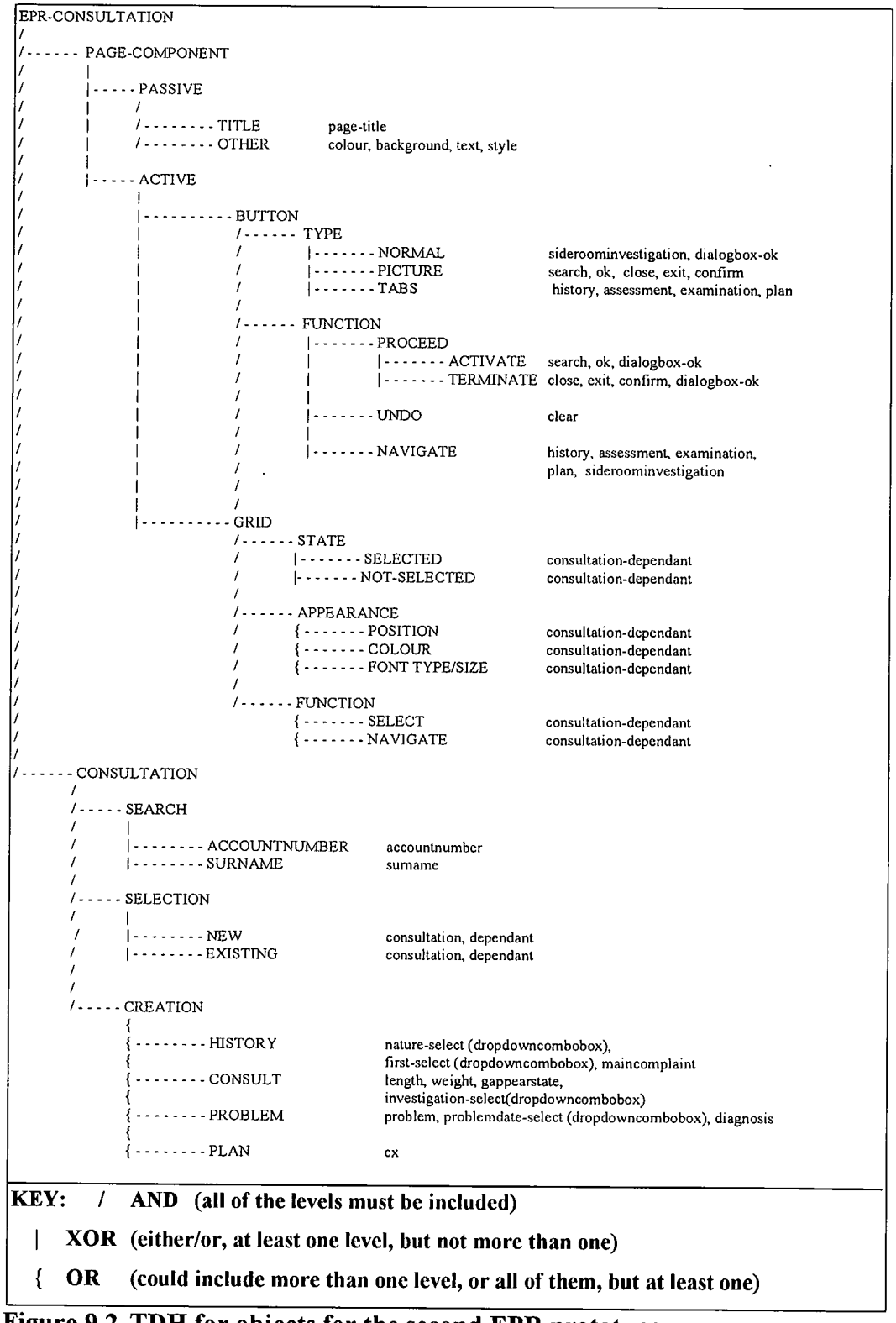


Figure 9.2 TDH for objects for the second EPR prototype

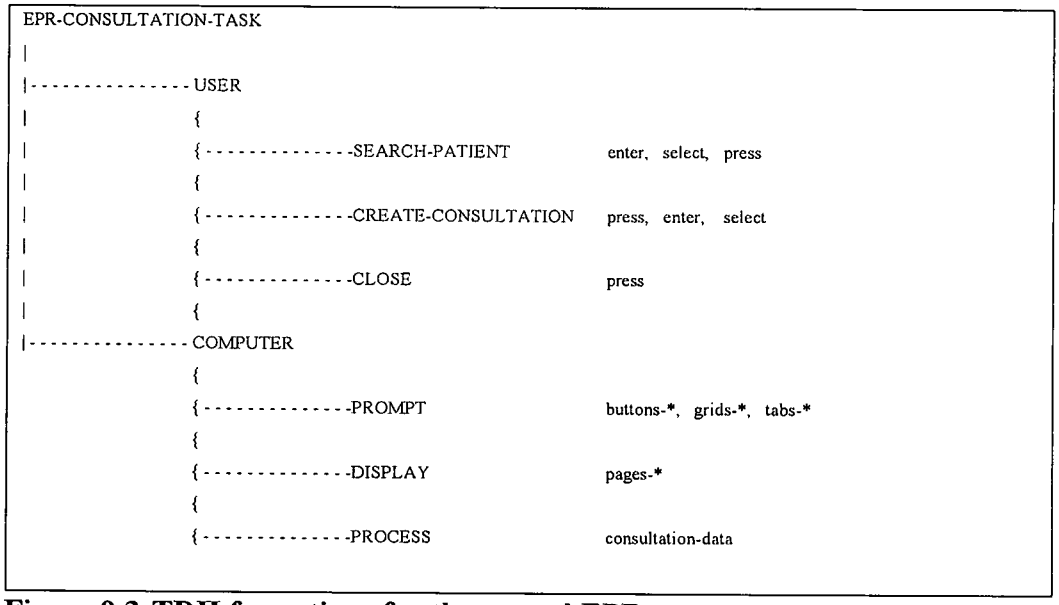


Figure 9.3 TDH for actions for the second EPR prototype

* The asterisk indicates that a variety of buttons, grids, tabs, and pages are represented.

- Task descriptive hierarchy (TDH)

The TDH derived from the specific object list for the first prototype is presented as Figure 9.2, while the TDH for the specific actions is presented in Figure 9.3.

The major changes to the TDH, when compared to the TDH for the first prototype (refer to Chapter 6), are the following:

- Addition of *tabs* as a type of button
- Addition of the dialog box components (e.g. dialogbox-ok button)

The fact that only one grid-object is listed on the final level might raise questions as to the validity of a separate grid level. This was the result of the fact that the TDH was drawn up for a specific task. In many of the tasks that will be performed using the second prototype, other grid objects will, however, be used. It was, therefore, deemed meaningful to leave the grid as a level on the TDH.

- KRG sentences

Before generification, the following sentences may be derived to describe the three sub-tasks (search patient, create consultation, close system) contained in the detailed problem statement for creating an EPR consultation using the second prototype:

SEARCH-PATIENT:

EPR-consultation-task (search-patient)
press button/function(proceed(activate))/ *search*
EPR-consultation-task (search-patient)
enter consultation/search(accountnumber) *accountnumber*
EPR-consultation-task (search-patient)
enter consultation/search(surname)/ *surname*
EPR-consultation-task (search-patient)
press button/function(proceed(activate))/ *dialogbox-ok*
EPR-consultation-task (search-patient)
select grid/function(navigate)/ *consultation-dependant*

CREATE-CONSULTATION:

EPR-consultation-task (create-consultation)
select consultation/selection(new)/ *consultation*
EPR-consultation-task (create-consultation)
press button/function(navigate)/ *history*
EPR-consultation-task (create-consultation)
enter consultation/creation(history)/ *maincomplaint*
EPR-consultation-task (create-consultation)
press button/function(navigate)/ *examination*
EPR-consultation-task (create-consultation)
enter consultation/creation(consult)/ *length, weight,*

gappearstate

EPR-consultation-task (create-consultation)
press button/function(navigate)/ *sideroominvestigation*
EPR-consultation-task (create-consultation)
enter consultation/creation(consult)/ *investigation-select*
EPR-consultation-task (create-consultation)
press button/function(proceed(activate))/ *ok*
EPR-consultation-task (create-consultation)
press button/function(proceed(terminate))/ *close*
EPR-consultation-task (create-consultation)
press button/function(navigate)/ *assessment*
EPR-consultation-task (create-consultation)
enter consultation/creation(problem)/ *problem, problemdate-select*
EPR-consultation-task (create-consultation)
press button/function(proceed(activate))/ *ok*
EPR-consultation-task (create-consultation)
enter consultation/creation(problem)/ *diagnosis*
EPR-consultation-task (create-consultation)
press button/function(navigate)/ *plan*
EPR-consultation-task (create-consultation)
enter consultation/creation(plan)/ *cx*
EPR-consultation-task (create-consultation)
press button/function(proceed(terminate))/ *confirm*
EPR-consultation-task (create-consultation)
press button/function(proceed(terminate))/ *dialogbox-ok*

CLOSE-PROGRAM:

EPR-consultation-task (close-program)
press button/function(proceed(terminate))/ *exit*
EPR-consultation-task (close-program)
press button/function(proceed(terminate))/ *dialogbox-ok*

During generification, some of the above-listed KRG sentences were combined, or generalised, to produce the final set of user-agent KRG sentences presented in Table 9.24. Eventually five distinct sentences were derived from the sentences above.

EPR-consultation-task (search-patient)
enter (consultation/search/)
EPR-consultation-task (search-patient)
select grid/function/
EPR-consultation-task (create-consultation)
select consultation/selection(new)/
EPR-consultation-task (create-consultation)
enter consultation/creation/
EPR-consultation-task (*)
press button/function/

Table 9.24 Final set of user-agent KRGs for the second EPR prototype

Strictly speaking, the selection of a new consultation is implicit. Therefore, the KRG sentence:

EPR-consultation-task (create-consultation)
select consultation/selection(new)/

could be left out. This would then result in four final user-agent KRGs.

The same principles that were used to derive the results portrayed in Table 9.24 can be applied to reach the final set of computer-agent KRGs presented in Table 9.25.

EPR-consultation-task(*)
display (page)
EPR-consultation-task
prompt (one-of-three-user-agent-actions)

Table 9.25 Final set of computer-agent KRGs for the second EPR prototype

- KRG sequence analysis

(1) enter (account-number)
(2) select (dependant)
(3) press (history-tab)
(4) enter (main-complaint)
(5) press (examination-tab)
(6) enter (length, weight, general-appearance-state)
(7) press (sideroom-investigation-button)
(8) select (sideroom-investigation)
(9) press (ok-button)
(10) press (close-button)
(11) press (assessment-tab)
(12) enter (problem, problemdate)
(13) press (ok-button)
(14) enter (diagnosis)
(15) press (plan-tab)
(16) enter (cx)
(17) press (confirm-button)
(18) press (dialogbox-ok-button)
(19) press (exit-button)
(20) press (dialogbox-ok-button)

Table 9.26 SRG for second EPR prototype

As was the case in Chapter 6, the SRG presented in this section (Table 9.26) was derived from the complete list of KRGs and is presented in a lower level format as in some examples found in task analysis literature. As was mentioned before, this was done intentionally to emphasize some of the problems as identified in the task analysis as well as for clarity purposes.

- Discussion of task analysis results.

The discussion of the task analysis results will be headed off by comparing certain aspects of the task analysis of the second and the first prototypes. This will be followed by problems identified and insights gained regarding the second prototype specifically. It must again be stressed that some of the aspects mentioned in this discussion might be a repetition of conclusions reached during the other evaluation methods described in this chapter. As was the case in Chapter 6, however, it was deemed important to show that the task analysis yielded similar results.

The value of task analysis comes to the fore when comparing the task analysis exercises for the first and second prototypes. Although the task activity lists for the two prototypes differ considerably, the final sets of KRGs are very similar. This illustrates how two systems, differing in "content", may still yield similar general task descriptions as a result of generification.

The main problems highlighted by the first prototype task analysis were the unnecessary use of the OK-button, the unnecessary navigational buttons that forced the user to follow certain paths and the cumbersome logoff procedure when leaving the system. Did the second prototype improve on the first prototype in these regards? The following paragraphs will attempt to answer the question.

Considering the task activity lists again, the second prototype appears to be a simplification of the first prototype. One hundred and twenty one activities were identified for the second prototype in comparison to the 136 for the first (remember that exactly the same task was under scrutiny for the task analysis of both these prototypes). This reduction in activities occurred despite the fact that more confirmation dialog boxes were introduced in the second prototype to serve as error prevention methods (e.g. exit confirmation dialog box).

Moving along to the number of specific objects identified in the specific object lists, the difference between the two prototypes is negligible (106 for the first and 105 for the second prototype). The same can be said regarding the number of computer-agent activities (97 for the first and 96 for the second prototype). When considering the number of user-agent activities between the two prototypes, a different tale is told. It seems as if the second prototype (with 27 user activities) addressed the problem of unnecessary user activities of the first prototype (35 user activities). It is believed that this improvement can mainly be attributed to the introduction of the tab-method for navigation. This gives the user the freedom to change the order of entering a consultation according to personal preference. It also provides the user with a visual reminder of the scope of the system, as all the available options are constantly visible at the top of the screen. The ease with which the user may move among different screens in the second prototype is also detectable when comparing the original lists of KRGs of the two prototypes.

The reduction in the use of the OK-button in the second prototype becomes evident when comparing the SRG's of the two prototypes. In the first prototype SRG the OK-button had to be pressed five times, while only twice in the second prototype.

Replacing the double pressing of the close-button with a single exit-button press relieved the effort needed to exit the first prototype. This exit-button is also

permanently visible at the bottom of the screen. The user is, therefore, supplied with an "emergency exit" to be used at any time during the consultation. The fact that an additional user action is expected to confirm the exit-command is viewed as a necessary precaution to prevent the user from accidentally leaving the system. It is not seen as a complicating intermediate step, but rather the application of a good user interface design concept.

Drawing the attention to the insights gained from the second prototype task analysis specifically, the value of defaults (static defaults in particular) was highlighted. In comparison to the first prototype, where the user explicitly had to select the nature of the consultation and whether it was a first or follow-up visit, these options were presented to the user as defaults in the second prototype. The same principle was applied on the Assessment screen to simplify the entering of different problems. The current consultation date was supplied as default in the problem date field. During the observational sessions the latter already seemed to simplify the user's task tremendously. This simplification is also evident when comparing the SRG's for the two prototypes.

The placing of the general appearance options on the Examination screen, in stead of on a separate screen (as was the case in the first prototype), also contributed to less user activity.

Therefore, referring to the question asked at the beginning of this discussion, it is safe to conclude that, according to the task analysis results, the second prototype did improve on the first.

9.5.3 Discussion of usability testing results

Table 9.27 contains a summary of the results of the qualitative and quantitative evaluations. It depicts the first and second prototypes' adherence to the usability properties. When glancing at the qualitative columns on the table, it is clear that the

second prototype adhered to these principles much better than the first prototype. The 17 ticks in the "Yes"-column of the second prototype in contrast to the 4 in that of the first prototype confirm this statement. Further evidence is the 7 ticks in the first prototype's "No"-column in contrast to none in that of the second prototype.

	QUALITATIVE						QUANTITATIVE	
USABILITY PROPERTIES	FIRST PROTOTYPE			SECOND PROTOTYPE			SIGNIFICANTLY DIFFERENT	
	Yes	Partially	No	Yes	Partially	No	Yes	No
Learnability								
Predictability		✔		✔			✔	
Synthesizability	✔			✔				✔
Familiarity	✔			✔			✔	
Generalizability			✔		✔			✔
Consistency		✔		✔			-	-
Interaction metaphors		✔		✔			-	-
Visual clarity		✔		✔			-	-
User guidance & support			✔		✔		-	-
Enjoyability		✔		✔			-	-
Conceptual models	✔			✔			-	-
Flexibility								
Dialogue initiative			✔	✔			✔	
Multi-threading			✔	✔				✔
Task migratability		✔		✔			✔	
Substitutivity		✔		✔				✔
Customizability			✔		✔			✔
Control			✔	✔			-	-
Robustness								
Observability		✔		✔			✔	
Recoverability		✔			✔		✔	
Responsiveness	✔			✔			-	-
WYSIWYG			✔	✔			-	-
Task conformance		✔		✔			✔	

Table 9.27 Summary of the two prototypes' adherence to the usability properties (according to the qualitative and quantitative evaluation)

The remainder of this section will be dedicated to the discussion of the quantitative test results.

It has been mentioned in the qualitative evaluation for predictability that neither of the two systems provided for a formal on-line help facility. Despite this fact, slightly more assistance was required for the use of the first prototype than for the second. The

difference might be contributed to the provision of hints in the second prototype. From the results it is also gratifying to note that the users did generally not experience frustration while using either of the prototypes.

It did not come as a surprise that there was no significant difference between the two prototypes when the number of messages appearing in the status bar was compared. This corresponded to the qualitative evaluation performed for synthesizability where it was stated that both prototypes faired well in this regard.

When considering the prototypes' adherence to familiarity, a significant difference was measured in the time spent on errors and in the number of errors. This means that the number of errors made when using the first prototype was more than when using the second. The second prototype allowed the user to recover from these errors much faster than in the case of the first prototype.

Users did not seem to have a problem using the Tab-key to move around on a screen in stead of the Enter-key. This is in agreement with discussions held with the users during post-task walkthroughs. The general opinion was that if a user was accustomed to pressing the Enter-key for navigation, he/she became used to the Tab-key fairly quickly and did not find it a hindrance. Therefore, as both prototypes expect the user to use the Tab-key, both support generalizability equally when considering this criterion.

Another "non-surprising" situation resulted from the tests that were performed to determine the number of times that the user was prohibited from following a specific path. These results confirmed the heuristic and qualitative evaluation outcomes in that the user has much more freedom in the second prototype to pre-empt the dialogue than in the first prototype. This can mainly be contributed to the introduction of the tab-method.

In both the first and the second prototypes provision has been made to utilize both the mouse and the keyboard. This is especially true of button-use. With both being windows-

applications, it therefore came as no surprise that there was no significant difference in the way the two prototypes supported multi-threading.

In the qualitative evaluation of the task migratability principle, it was stated that the second prototype supported this principle better than the first. This statement was confirmed by the results of the quantitative tests. These results (Table 9.14) indicate a significant difference between the number of times confirmation is asked from the user when performing crucial tasks in the second prototype in comparison to the first prototype. The additional confirmations to the second prototype (when saving a consultation and leaving the system) are viewed as the two main contributors to the improvement.

In both the first and the second prototypes output presented in grids may be used as input to the system to gain access to detailed information. This explains why no significant difference was indicated in the qualitative test results when these output-input substitution occurrences were measured. Therefore, measured in view of this criterion, the substitutivity principle is equally supported by both the prototypes.

The prototypes' adherence to the customization usability property was measured by the number of times the users would have liked different options/values to choose from. These results (Table 9.16) did not show a significant difference between the two prototypes in this regard. The qualitative evaluation indicated a great enhancement in customizability in the second prototype with the provision of the *Maintain*-option. The reason for this improvement not being reflected in the quantitative evaluation may be found in the nature of the tasks that were presented to the users to perform. The task instructions were very specific and did not really allow for this aspect to be tested. Therefore a limitation in the design of the task sheet can be held responsible for this discrepancy.

In the qualitative evaluation the attempt of the designer to include more default-values in the second prototype was acknowledged. This was confirmed by the results of the

quantitative evaluations performed. There were significant differences in the occurrence of both static and dynamic defaults in the two prototypes. Considering the average values (Tables 9.17 and 9.18), they indicate that more defaults were found in the second prototype. This leads to the conclusion that, considering defaults, the second prototype is much more observable than the first.

Testing the recoverability of the two prototypes yielded interesting results. Although the time duration for error correction indicated a significant difference between the two prototypes, this was not the case when the number of steps taken to perform corrective action was considered. The reasons for this state of affairs are quite simple: it has been mentioned that more confirmation is expected from the user in the second prototype than in the first. These confirmations (and associated actions/steps) were added to the number of steps that was necessary to correct the error in the second prototype and to conclude the consultation. Therefore, although the ease of making corrections might be perceived as being much simplified in the second prototype (as was indicated with the time measured to make a correction), the number of steps necessary to make that correction, still remained the same.

The quantitative evaluation of the task conformance principle, as well as the task analysis, confirmed the results of the heuristic and the qualitative evaluations, namely that the second prototype was simpler and therefore quicker to use than the first.

9.6 Conclusions

The conclusions will be presented in two parts. The conclusions reached from evaluating the second prototype will be presented first, followed by the conclusions reached from the evaluation of the HUB Computer Medical System.

9.6.1 The Second Prototype

From the results of the query techniques it was evident that most evaluators were of the opinion that this EPR prototype was a step in the right direction. Satisfaction with the user interface was expressed. The modified user interface seemed to be a great improvement on the first prototype. The freedom of movement among different screens was also received kindly. The fact that the system is easy to understand and to learn particularly impressed them. This was proven by the fact that none of those who took installation disks with them in order to evaluate the program at home/their practices (in other words, all of the participants!), reported any problems with the installation, running or functioning of the program. The user interface, in conjunction with the limited paper support, was sufficient help to be able to use the system.

The major critique against the system is the time factor. Most of the evaluators stated that it was too time-consuming to use in a busy practice. This seems to still be true even if one considers that the system is still new and foreign to them, and would therefore be more time-consuming than their current systems that they have been using for the past couple of years. It is, therefore, a critique that should be taken very seriously.

A factor that must, however, be taken into consideration as a mitigating circumstance, is that some of the participants were not in the position to first have a demonstration or an explanation of the system before using it for the first time. As mentioned before, the consultation example handed to them was done in much detail, for specific reasons. It was done to ensure that the evaluator formed an impression of the complete system. All the possible functions were included in the example. From reading some of the comments on the evaluation forms, it is evident that some physicians were under the impression that it is always compulsory to enter all the information stated in the example. This would, naturally, make the system seem more cumbersome and time-consuming. When explaining that a medical note can be created by entering the main complaint only and by then pressing the "Confirm this consultation" button on the Plan screen, they grasp an important aspect of the system, namely freedom of movement and use.

Returning to the point that the time constraint issue should be taken seriously, it is evident that physicians would prefer making choices from lists in contrast to typing. The pre-condition is, however, that they would like to add these choices from which to choose themselves. On the other hand, they would not like to be constrained when a non-standard entry is necessitated. Provision should, therefore, still be made for typing information. More about this matter will be said in the following chapter.

The query technique's results indicated that the users were satisfied with the second prototype's user interface. This was confirmed by the heuristic evaluation results. The visibility, consistency and standards, and the tab method greatly enhance the user interface. The heuristic evaluation also confirmed the prototype's ease of use and learning, as was proved by its adherence to the "error prevention", "recognition rather than recall" and "flexibility" heuristics. The advantage of the tab-method was elaborated upon in the heuristic test results, specifically with the prototype's compliance to matching the real world situation and providing the user with control and freedom. The heuristic tests also highlighted shortcomings, the most important being the absence of a formal help facility and solutions that need to be included in error messages.

The results of the usability testing confirmed many of the observations made during the query techniques and heuristic evaluations. The most important aspect is that dialogue initiative, and more specifically user pre-emption, has been improved tremendously by the addition of the tab-method. The time-issue, as identified from the query techniques, was also addressed. Although users had fears regarding the time it would take to create a consultation, the quantitative evaluations indicated that it was already much quicker to create a consultation in the second prototype than in the first. This was evident even after the effect of learning transfer had been provided for (five of the ten subjects tested the first prototype first, while the other five were first presented with the second prototype).

Generally speaking, the quantitative evaluations confirmed much of what was addressed in the qualitative evaluations.

9.6.2 The HUB Computer Medical System

Despite some concerns pertaining to the HUB Computer Medical System (which will be covered shortly), the evaluators identified certain positive aspects about the system. The fact that selections could be made via the mouse was received positively. This contributed towards a perception of a "speedy" system. Although the HUB is of American origin and many of the codes and billing issues used are specific to the United States health care system, the principle of linking the diagnosis, for example, to existing code structures, was also seen as a positive point. Another convenient aspect identified in the system, is the inclusion of a scheduling function where the receptionist can schedule patients early in the day to allow the physician to easily call up the particular patient's record.

The concerns regarding the HUB as mentioned above are mainly two-fold. First, as can be deducted from some of the remarks included in Table 9.4, the evaluators deemed the system as being cumbersome as a result of too much detail. They experienced a feeling of "drowning" in too many choices.

The second concern relates to the principle of Foresighted Practice Guidelines. The key to the success of HUB lies in the building of FPGs. Why has the Practice Guideline effort failed so far? Why is it not widely used and accepted? The definition of Clinical practice Guidelines, namely "*The systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific circumstances*", describe the two models, namely the Foresighted model and Hindsighted model (refer to Chapter 2). The first effort to bring practice guidelines under the attention of the world was by a team of PhDs from the Institute of Medicine. A paper was written and a definition was made. The people involved with the paper were neither working physicians nor working system analysts.

While a few of the people involved who were trained in medicine and systems analysis recognised the two models, those not trained in both fields only understood it as a hindsighted model, the Hindsighted Practice Guideline Model. Working community

physicians were quick to recognise that the Hindsighted model was just cook book medicine and that there are too many variables to approach care in this way. Others involved superficially with medicine embraced the idea. Apparently they did not understand that medicine is a process and that the diagnosis is the end point. They reasoned that physicians approached patient care from the end point, the diagnostic conclusion. This confusion between the two models is said to have created prejudice against, and therefore harmed the FPG model [Naegele 1997].

Some other questions that were raised in the evaluation results are:

- *Who is going to draw up the guidelines?*
- *Who will be responsible for updating the guidelines?*
- *Who will accept responsibility for the guidelines?*

Regarding the question relating to who will draw up the guidelines, the perception is that physicians who are highly regarded in the medical field, specifically in the field of Family Medicine, should be involved in the exercise. General practitioners should feel confident using the guidelines, and they will only feel that confidence when they believe in the competence of the guideline designers. It must be born in mind that it will take building at least fifty guidelines to get the idea clear in one's mind. It will therefore be a time-consuming exercise [Naegele 1996a].

With respect to the responsibility of updating the guidelines and ensuring that they are relevant, doubt has been expressed as to whether prominent physicians will have the time (or willingness) to make the effort. Without the assurance that the guidelines used in a particular system are relevant, the whole exercise will be futile. Overall responsibility for the guidelines, for instance in medico-legal cases, still has to be examined thoroughly. Concluding the concerns regarding using FPGs in an EPR system, it has been mentioned that using FPGs could easily suffocate a physician's creativity when examining a patient. It might be that a physician is (unconsciously) lead by the FPG towards a specific diagnosis, while other options should have been investigated.

9.7 Summary

In this chapter the evaluation procedure and results of evaluating the second and third prototypes were discussed. While positive aspects of both systems were highlighted, the attention was also focussed on potential problem areas. Regarding the second prototype, the ease of movement among the different screens, as well as the user interface were applauded. The main concern, on the other hand, centers on the time factor. Providing the user with choices to click on, was perceived as the most important plus factor regarding the HUB, while too much detail and problems relating to the Foresighted Practice Guidelines were highlighted as the main concerns.

In considering the evaluation results of both these systems, as well as all the information in this thesis so far, Chapter 10 will present a model for the development and implementation of an EPR system for general practitioners in South Africa.

Chapter 10

Recommended EPR Model

10.1 Introduction

In the previous chapter the second prototype and the HUB system were evaluated. Consequently certain conclusions were drawn from these evaluations. When considering these conclusions in conjunction with all the information contained in this thesis up to this point, the question being asked is: "*What should an EPR system directed towards use in general practice in South Africa look like?*" In the following paragraphs an attempt will be made to present the reader with a model of such as system. This model will then be assessed to determine its compliance with previously identified EPR needs and requirements of South African GPs.

10.2 Recommended EPR model

It is strongly believed that the second EPR prototype, as it is, could successfully be used as the starting point for building a generally acceptable South African EPR system. The evaluation results indicated that the user interface is appealing and acceptable, it is easy to understand, and easy to learn.

Should one try something totally different with the user interface? Some of the current medical record computer programs on the market start with a picture of the human body so that the user can point at the body part with the problem. Non-medical professionals love this idea because this is how they think. The first question a physician with no computer training will, however, ask is "*Where does one click when the patient complains of dizziness, weakness, high blood pressure, etc?*"

Worldwide-web browsers offer a new alternative to user interfaces. As long as privacy can be protected, web browsers could display an EPR, relevant reference material, and journal medical records – all together! Despite its obvious advantages, current web browsers, however, constrain data design. The browser, with its controls, icons, buttons, and toolbars takes command of many screen pixels. The operating system's menu bar, taskbar, and desktop icons make the situation even worse [Powsner 1998]. The main reason for not utilising the Web as user interface is the specific circumstances in South Africa. Many of the physicians, for example, do not have access to the Internet yet. In order to present an EPR system to the broad spectrum GP in SA, the Internet is therefore not an option at present. With these issues in mind, it was decided to stick to the simple, but effective user interface of the second prototype.

It must be stressed, however, that the second prototype will be used as a *starting point* – the prototype could definitely not be used in practice in its current state. As mentioned before, the system was meant to be a prototype, where principles were tested and evaluated. This intention has been met. The system, in principle, is acceptable to physicians. There are, however, many changes that were recommended that need to be addressed.

In the following section a description of the recommended EPR will be given. This will be followed by an explanation of how the EPR model would interact with the Health Care environment.

10.2.1 A description of the recommended EPR model

In summarizing the most important features of the recommended EPR model, two main aspects will be highlighted, namely its user interface and functionality.

- **EPR model user interface**

  The EPR model should be a Windows application. It should have a graphical-based user interface where direct manipulation and form filling interaction styles are

combined. The keyboard and mouse should both be used to accomplish human-computer interaction.

The main departure point for the model's user interface should be simplicity, or more precisely, functional simplicity. The prospective user community of the EPR is South African general practitioners. Therefore the computer skills of the prospective users vary from none to expert. These users should be able to use the EPR as a tool in conducting patient consultations. The *functional simplicity* mentioned earlier would therefore require an understandable, easy-to-learn, easy-to-use, but functional user interface. The user interface should, in effect, disappear in order to allow the physician to concentrate on the task at hand.

Using the tab-method as basis could contribute largely towards a successful user interface. This would allow for freedom of movement within the EPR – the user would not be forced to follow certain pre-defined paths. The user is thus presented with a feel of control – a major contributor to successful human-computer interaction. The tab-method would also contribute towards the requirement of a "short consultation", where the consultation should be created in as few steps as possible.

Throughout the EPR model, the user should be presented with options where choices among different values are applicable. The use of combo box and grid components in the user interface would make this possible. In a further attempt to facilitate ease of use, ample provision for default values on the EPR screens should be made. The most popular choices are displayed in edit fields or combo boxes, permitting modification of these values if so required. The selective use of specialized screen components, for example calendars, could greatly enhance the user interface. In stead of typing the date (with possible resultant typing errors), the user is presented with a visual calendar where the date may be selected using the mouse to click the appropriate day.

The recommended main colour for application in the EPR model is the popular Windows gray. This could be supplemented with teal (specifically as a grid colour). In cases where it is deemed essential to attract the user's attention immediately, red could be used (for example to display the patient's allergies). The above-mentioned colour scheme was positively received by the users and was considered to be "soft on the eyes". This is important when considering the circumstances in which an EPR will be used – in busy general practices with physicians with more than their fair amount of daily tasks to perform, as users!

- **EPR model functionality**

A prospective user should gain access to the EPR model via user identification and a password. In cases where more than one physician works in a specific practice, a list of physicians may be presented on the first screen. When selecting the appropriate physician, the corresponding password, therefore, needs to be entered.

In order to comply with the way patient records are currently kept, the EPR model should follow the notion that every patient belongs to a family. The family information pertains to the person responsible for the account. A family, therefore, needs to be selected/created before a specific patient can be addressed. A family may be searched for by entering search criteria. In the case of the EPR model, searches may be conducted on family account numbers or by entering the complete/part of the family surname. The search feature may be extended to allow for searching on a first name, address, birth date or medical aid. When located, demographic information regarding the family should be displayed. A list of patients "belonging" to the family should follow. By selecting the appropriate patient, demographic information pertaining to the specific patient should be displayed. An important addition to the patient screen may be the patient's allergies listed in red (where applicable).

Another important aspect regarding the recommended EPR is a list of past consultations that might be displayed on the patient screen. These consultations

should be listed according to the dates and times of occurrence. By selecting a consultation date, the information captured during the specific consultation (the medical note) is displayed on the screen. The user should also have the option to print the note. Consideration should be given to the WYSIWYG usability principle here to ensure that the printed version resembles the version on the screen.

The capturing of the clinical note should be done according to the internationally accepted SOAP model. The four screens containing the information required by the SOAP model will now briefly be discussed in turn.

- **History(S) screen** – The History screen should contain two different types of information. The first type is basic information pertaining to the current consultation, namely the consultation date and time, the attending physician, the nature of the consultation, whether it is a first or follow-up consultation, and the main complaint of the patient. The second type of information on the screen involves the patient's medical history. This includes screens for entering/modifying/deleting previous illnesses, operations, injuries, investigations, medications, and allergies. The family history and general profile, as well as systemic history of the patient may also be entered.

- **Examination(O) screen** – The basic patient parameters (including the body mass index and indicators regarding this index and the abdominal circumference, e.g. "obesity"), the vital signs, general appearance, systemic examinations, and side room investigations should be captured on this screen.

- **Assessment(A) screen** – The problem list should be created on the assessment screen. Problems, problem dates, outcomes, and outcome dates are added or modified. Extensive viewing facilities could also be provided for. The user could be given the choice of viewing the whole problem list, problems between two date ranges, all the active problems, or all the active problems between two date ranges. The differential/final diagnosis may also be entered on this screen.

- **Plan(P)** – The Plan screen should allow for entering Dx, Rx, and Cx information. When selecting a new Dx investigation, provision should be made to view the results of previously entered investigations. To assist in entering Rx information, the patient's allergies (where applicable) should again be listed. Provision should also be made for indicating a follow-up consultation date by presenting the user with a visual calendar.

The user should be allowed to move among these four screens as desired until a confirmation button is pressed. Once the consultation is confirmed (a confirmation message is displayed to allow the user to change his/her mind), no changes may be made in order to comply with medico-legal terms. To accommodate for human error, a Modify facility should be provided for. This should allow the user to attach notes to existing consultations by selecting the specific date and time of the previous consultation.

It often happens that a physician is interrupted by a phone call during a specific consultation. If this interruption is in respect of a query regarding another patient, the recommended Query facility in the EPR model will allow him/her to cope with the situation. The physician may leave the current consultation screen, move to the Query screen, retrieve the patient record in question, answer the query (by looking at a previous consultation), and subsequently return to the consultation screen where he/she left off.

The recommended Maintain option provides for limited customization. Lists presented to the user on various screens are maintained here. Options may be added, modified, or removed. The lists that should (at least) be provided for in the EPR model are titles, languages, marital status, medical funds, relationships, systems, consultations, Dx, and investigations.

It is important to note that the user should be allowed to exit the system at any time during the consultation. An exit-button should constantly be visible at the bottom-right of the screen. In an attempt to avoid the accidental pressing of buttons, a confirmation message should be displayed to confirm the user's intention of leaving the system.

As a result of the extensive evaluation that was performed on the two prototypes, it is essential that the following issues should be emphasized and subsequently incorporated into the EPR model.

- One of the major issues that needs to be incorporated involves a positive aspect identified in the HUB Computer Medical System. Using the second prototype took up too much time. The major reason for this time aspect was the amount of typing needed to create an electronic consultation. Computer illiteracy/inability to type contributed substantially to this state of affairs. This is where lessons can be learned from the HUB system. In this system, the minimal amount of typing is necessary. Most of the choices are made by using the mouse (in the version at the disposal of the author). The middle course between the two systems is therefore suggested. By presenting the user with choices to choose from, in stead of expecting them to type in information, the use of the recommended EPR model can be sped up. The user, however, does not want to drown in all the possible choices, or feel lost halfway during the use of the system use. The suggested solution to finding this middle course is to allow the user to fully customize his/her choices. This implies that the user may, for example enter his/her own choices that should appear in the drop-down combo boxes. To accommodate the users who would prefer the extra freedom of typing information, memo fields can be provided on request. In this way the fast point-and-select principle utilized in HUB, can be incorporated into the EPR model.

  The above-mentioned possible solution is one suggestion to help solve the time problem associated with the second prototype. What other options exist? Another

way to address the problem, as was suggested by one of the evaluators, is by providing the user with a "long" and a "short" consultation. A "long" consultation implies that all the information, as is currently combined in the EPR model, is presented to the user. The "short" consultation, in contrast, will only consist of a *minimal data set*. This would imply that only absolutely essential information would be captured on this screen. The option of a "short" consultation could be presented to the physician as a totally separate system, or as an extra screen within the existing system. The author would suggest the latter, *if* this time-reduction option were to be pursued. As the evaluators of the second prototype indicated that they were, in principle, satisfied with the screen layout, organisation and content thereof (with the indicated additions, of course), it is suggested that these aspects should be kept intact and therefore incorporated into the model. A separate screen with only essential information on it could then be added. This would, however, imply that consensus should be reached among physicians as to what *essential information* entails.

Another (simpler) option to consider (in contrast to providing a separate screen) is to provide easy access to the consultation confirmation button, as was also suggested by one of the evaluators. At this stage the user has to go to the Plan screen in order to save a consultation, as the above-mentioned button only appears on the Plan screen (refer to Figure 7.19). The easiest way to comply with this suggestion is to place this button at the bottom of the screen, on the left-hand side of the "Exit"-button. The "Confirm this Consultation"-button will then be visible and accessible from all the screens in the system. It will, therefore also facilitate a "short" consultation as the user can enter the main complaint and press the button without having to leave the current screen. The rest of the system will remain intact.

- Despite being "fast-using", what other features should this EPR model have? It should include a printing facility for the medical note, the reminder, and prescriptions. In addition to the patient's full first names, provision should be

made for the name with which the patient would wish to be addressed. The church denomination should also be transferred from the family to the patient screen. A report facility where ad-hoc queries for research purposes can be compiled, should also be included in the EPR model. Error messages should not only identify errors, but should include purposed solutions to the errors. An on-line help facility should form part of an EPR system and undo/redo actions should be possible. In order to comply with Windows standards, a cut/copy/paste facility should also be provided for.

- Although the following aspect has already briefly been touched upon before, it is important to provide for multiple levels of access to ensure security. One of the essential requirements in this regard is to allow the physician to determine the level of access that his/her receptionist may have. It is generally accepted that the receptionist will enter the demographic information of families and patients. Some physicians would, for example require the receptionist to additionally enter the results of specialist reports, or the patient's medical history into the system. The system should, therefore, provide for these different levels of access. As an additional feature, the receptionist could also be allowed to schedule patients, as was done in the HUB Computer Medical System.

- As far as the issuing of prescriptions is concerned, a decision of principle was made. The existing medical financial/administration packages, almost without exception, already cater for prescriptions. Re-inventing the wheel is not viable. Therefore a decision was made to provide for *limited* prescription functions to accommodate those physicians who do not have access to another facility. In the Rx information block a physician can compile a prescription that can be printed afterwards. The EPR model, as was previously discussed in this chapter, already provides for this function. What needs to be done additionally, is to provide the physician with customized options regarding the prescriptions. If dispensing is done in the consulting rooms, he/she should be able to draw up a list of medications (and associated information) that is available in their medicine

cabinet. This would allow him/her to fill out a prescription by clicking on the available options of his/her choice.

A visualised version of the recommended EPR model, as discussed in the previous two sections, is presented in Figure 10.1. Although the model has just been discussed, it is deemed necessary to briefly explain the visualised model to the reader for the sake of clarity.

Users gain access to the functionality of the EPR through the user interface (of which the basic requirements are listed on the figure). Multiple levels of access exist. Access may, therefore, be either unlimited (in the case of the physician(s) and indicated by a solid green line) or limited (in the case of the receptionist or nurse and indicated by a dotted red line).

After gaining access to the system, the user has three choices, namely:

- Search (via multiple criteria)/create/schedule a family: After locating/creating the family in question, a new patient record(s) may be created or existing patients' records may be viewed (links between Family and Patients).

  With the appropriate patient information on the screen, previous consultations may be viewed (link between Patients and Previous Consultations) and printed (link between Previous Consultations and Printer). A new consultation may also be created according to the SOAP model (link between patients and SOAP model). These consultations may vary in detail and length. Reminders, prescriptions, absentee letters, and ad-hoc reports may also be printed (link between SOAP model and Printer). When satisfied with the consultation, the consultation may be confirmed. This will cause the new consultation to be placed in the Previous Consultations (link between SOAP model and Previous Consultations).

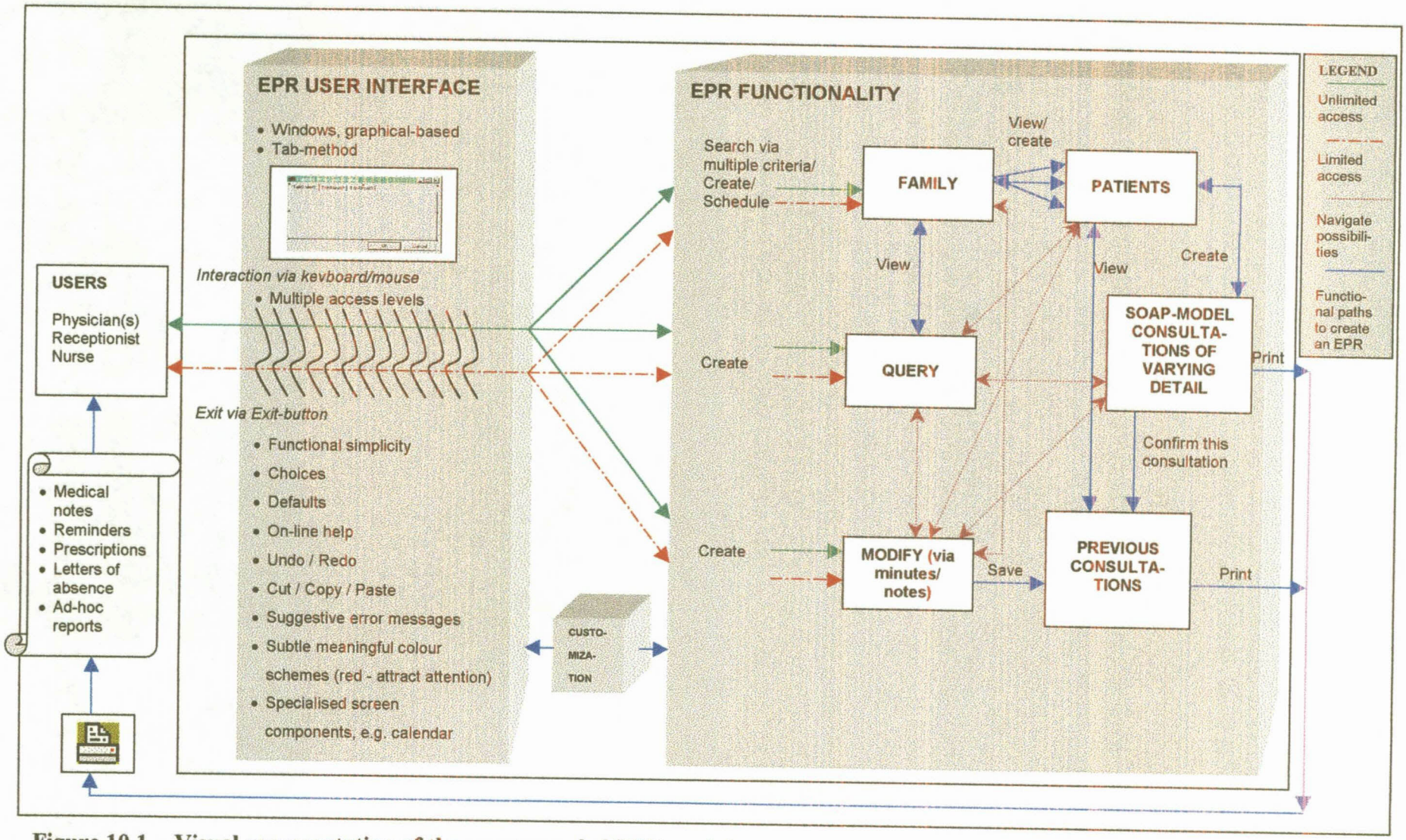


Figure 10.1 Visual representation of the recommended EPR model

- Create a query: When a query is performed, the user gains access (through the family) to the patient's demographic information, as well as the patient's previous consultations (link between Query, Family, Patients, and Previous Consultations).

- Modify a previously saved consultation: A previously saved consultation may be modified by attaching a minute/note to it.

The plum-coloured dotted lines linking the components within the functionality part of the model indicate that, once access is gained, freedom of movement is allowed. These lines show the possible navigation paths, for example between Patients and Modify, or between the SOAP model and Query.

In the next section an explanation will be given as to how the recommended EPR model would interact with the Health Care environment.

10.2.2 The EPR in the Health Care Environment

An EPR system on its own would not be viable in practice. Most physicians who use computers in their practices have some sort of financial/administrative medical computer system already in place. Building these financial/administrative functions into an EPR system would also be like re-inventing the wheel. Why do it when there are so many financial/administrative systems available on the market already? It should, therefore, be possible for an EPR system to link up to existing financial (or other, like stock control) packages. In Chapter 8 two interfacing standards appropriate to this thesis, namely HL7 [HL7 1999] and CEN TC 251 [CENTC251 1999] was mentioned. Naegele [1995] also indicated that MORF was used in the HUB system. Provision for linkage via these standards (or others that might be more appropriate to the specific circumstances) should be made.

The matter of links highlights the issue of linking with code structures (a requirement mentioned in the evaluation process). Recent changes in legislation and in Health Care in

South Africa have brought about new requirements that physicians need to adhere to with regard to medical aid companies. The requirements were necessary, among other reasons, to combat a growing tendency of fraud in medical aid claims. To fully understand all these coding requirements, physicians would need to attend a full-time course of a few days. The additional manual administration that was brought about with these changes requires additional resources in a medical practice. All these aspects will make it almost impossible for a physician to cope in future without a computer in a medical practice. This also brings about the need for a computer system to be able to handle these coding structures and the links to codes. The EPR program is the logical place where the linking should take place, as this is where diagnosis and procedures are determined.

From the results of the questionnaires (Chapter 4) and the evaluation results of the first and second prototypes (Chapters 6 and 9), communication links between the general practitioner and other role players in Health Care, for example pathologists, medical funds, radiologists, etc., have been ear-marked as of the utmost importance. As an example, a request for a specific pathological investigation should automatically be sent electronically to the specific pathologist as soon as the patient's consultation has been confirmed on the EPR system. The results of this investigation should then be returned to the physician, also electronically, and automatically linked to the patient's medical record. This procedure would imply easy access to an e-mail facility where the EPR program would handle the compiling of the message. A pre-requisite for this facility is that the other role players would also be geared towards this electronic contact. Many of these institutions, however, already make use of the electronic media, and it would only be a matter of time before the rest would follow suit. Two other popular methods to consider for communicating over networks are EDI and EDIFACT. Consideration can also be given to electronic communication with the patient. This could be useful for electronically sending, for example reminders to patients. The e-mail facility should therefore be added to the existing EPR system in order to contribute to our ideal EPR model.

The electronic contact with Health Care role players involves two special requirements. The first requirement involves the handling of X-ray images. The possible scenario here would be the following: the physician requests a specific x-ray investigation for a patient. As soon as the consultation is confirmed, a message is compiled and sent to the appropriate radiologist via e-mail. When the patient arrives at the radiologist, the request already awaits him/her. The consequent x-ray is then scanned at the premises of the radiologist and electronically sent to the requesting physician. Here it will be linked to the appropriate patient record. The physician will be warned that this image awaits his/her attention. The requirement for the proposed EPR model is to provide viewing and storing of this x-ray image (the e-mail aspect has already been mentioned above).

The second special requirement that electronic contact with role players brings to mind is that of specialist reports. Although the final prototype caters for these reports in that a summarised version may be entered into the system, quite a few physicians indicated during the evaluation that they would like to have a scanning facility. It goes without saying that they would need the scanning equipment in the first place. The EPR model would then have to provide for the viewing and storing of these scanned reports. This will be available as an additional option to the already mentioned one, as it is believed that, especially initially, only a few physicians will have access to scanning equipment.

Figure 10.2 illustrates the way in which the recommended EPR model would interact with the Health Care environment.

10.3 Assessing the EPR model

In Chapter 4 (Table 4.21) a summary of the needs and requirements regarding South African EPR systems was given. When compared to this list, does the proposed EPR model satisfy the needs, requirements, and expectations of South Africa general practitioners?

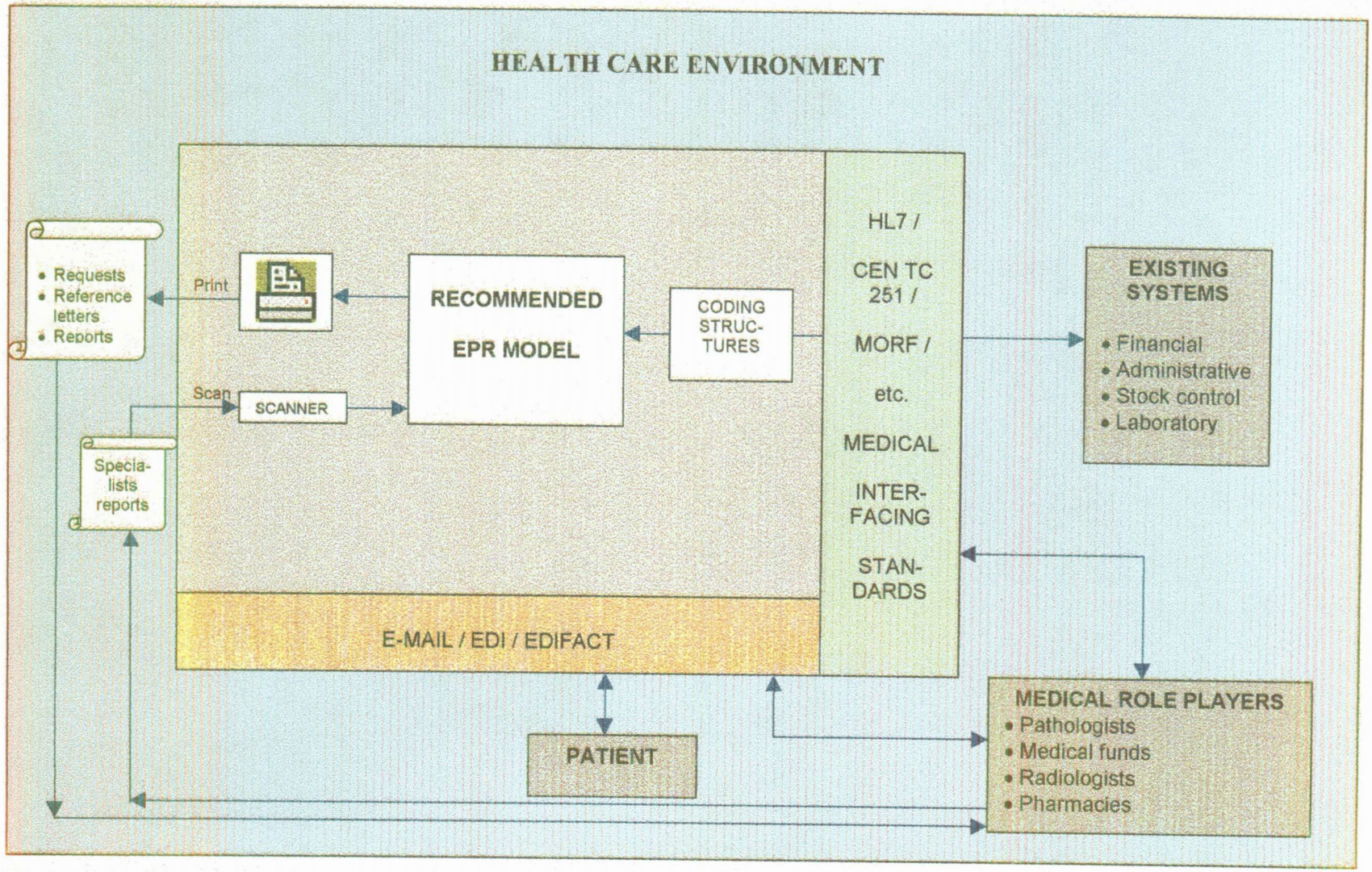


Fig. 10.2 Visual representation of interaction between the recommended EPR model and the health care environment

In an attempt to answer this question, Table 10.1 will reproduce the list of needs and requirements presented in Chapter 4 for the sake of convenience. Additionally, an indication will be given of the EPR model's compliance with these requirements.

ASSESSMENT OF THE PROPOSED EPR MODEL			
NEEDS AND REQUIREMENTS	COMPLIANCE		
	YES	PARTIAL	NO
A printed copy of the patient record should be provided in addition to the record on the computer screen	✔		
The EPR should be easy enough to use to allow the physician to give the patient the attention he/she deserves	✔		
It should be possible to retrieve (and create) a medical record in the presence of the patient	✔		
Dispensing should be possible	✔		
The EPR should have a "usable" graphical user interface	✔		
Information should be entered with the aid of the mouse and keyboard	✔		
The most important "utility result" of the EPR should be a well-organised text-based patient record (images where appropriate)	✔		
A printing facility to print notes, reminders, reports, etc. should exist	✔		
Electronic communication with e.g. pathologists, medical funds, specialists, laboratories, and radiologists should be possible	✔		
Electronic communication (via e-mail) with patients should be possible	✔		
It should be possible to record work performed outside the consulting room (e.g. house calls) in the EPR	✔		
Hand-written reports should be linked with the EPR	✔		
The EPR should be affordable	✔		
The duration of the patient encounter using the EPR should not be considerably longer than with the manual system		✔	
Computer illiteracy should be born in mind (limit typing)	✔		
The EPR should require a short training time (easy to learn)	✔		
The EPR should be secure and available	✔		
The EPR should function on a network as well	✔		
Financial and administrative information should be integrated with the clinical information via coding schemes	✔		

Table 10.1 An indication of the proposed EPR model's compliance with the needs and requirements of South African GPs

Table 10.1 indicates that the proposed EPR model is comprehensive in that almost all the needs and requirements of South African GPs for such a system have been met. The only "partially met" requirement concerns the duration of the consultation using the EPR. Although careful consideration has been given to this aspect in designing the model, the duration of the consultation will depend on many factors, e.g. the type of consultation, the computer literacy of the physician, and his/her thoroughness. The provision for entering "short" and "long consultations" makes it difficult to say "yes" or "no" in the table above.

10.4 Summary

The model described in this chapter constitutes the proposed EPR system. With the foundation laid in the final prototype, with the reassurance that this prototype is a step in the right direction (as one of the evaluators pointed out) and the input gained from the evaluation of both the prototypes and the HUB Computer Medical System, this model can be implemented and presented to the South African general practitioners as an EPR system brought about with the contributions and input of general practitioners themselves.

In Chapter 11 the conclusions drawn from the research project will be outlined. Possible future developments will also be discussed.

Chapter 11

Conclusion and the Future

After having presented an EPR model in the previous chapter, it is time to wrap up. This chapter will therefore start with the conclusions. A view ahead regarding the possible future developments will conclude the thesis.

11.1 Conclusions

As a result of the *external* and *internal* information explosions (especially the internal explosion!), physicians desperately need assistance to cope in their practices. The assistant who can provide such assistance is manifested in a computer, and in name ... the Electronic Patient Record System.

The purpose (incentive) for this thesis was the presentation of a model of an EPR system for use in general practice in South Africa. In the following section the realization of the initially set goals in accomplishing this purpose will be discussed. This will be followed by a discussion on the additional contributions of this thesis. Presenting the right of existence of the recommended EPR model will conclude the section.

11.1.1 Realization of the thesis goals

In Chapter 1, it was stated that an attempt would be made in this thesis to:

- Ascertain whether a need for EPR systems exists among general practitioners in South Africa
- Identify problems associated with current paper medical records used in general practices in South Africa

- Identify the requirements, expectations, and needs regarding EPR systems as seen from the viewpoint of general practitioners in South Africa
- Design and present prototype EPR systems for evaluation and testing by general practitioners in South Africa according to the requirements, expectations, and needs as mentioned above
- Conduct a usability assessment of the above-mentioned prototype EPR systems
- Present the general practitioners of South Africa with a model of a proposed EPR system, designed for their specific requirements, expectations, and needs.

The realization of each of these goals will now be briefly discussed in turn.

- **Ascertain whether a need for EPR systems exists among general practitioners in South Africa**

  The results of questionnaires sent out to a randomly selected group of practicing GPs, indicated that South African general practitioners do not yet use EPR programs in their practices. Despite this fact, these general practitioners indicated that they see a need for it, are excited about the prospect and would use such a system should a generally acceptable system be available.

- **Identify problems associated with current paper medical records used in general practices in South Africa**

  Research conducted for this thesis indicated that over the years, a magnitude of serious problems with currently used manual medical record-keeping systems was encountered worldwide. The results of the questionnaires indicated that South Africa was no exception. Problems that were identified included lost, mis-filed, duplicate, dilapidated and obsolete files. A very important problem was highlighted, namely that data in paper files, filed in filing cabinets, could not be utilised in a meaningful manner. It could be viewed as a valuable treasure chest waiting to be opened in order

to provide meaningful statistics and reports. It is generally accepted that the computer would constitute the "treasure chest opener".

Despite the problems associated with current paper medical records, some physicians still have their doubts about many aspects of an EPR system. People seem to have pre-empted ideas/fears of computers, and some are simply prejudiced. When confronted with their current situations, where a manual medical record system is used, they often realise that their doubts and fears concerning computer-use are just as applicable to their current situations. On the other hand they might realise that a computer may present better solutions than their manual systems. It is interesting to note that most of these doubts can be brushed away with very simple arguments. An argument against using an EPR system in the presence of the patient can be defended by drawing the attention to the fact that manual records have been taken in the presence of the patient for years. How was this done? By first listening to what the patient had to say, and then writing it down. Why not hear the patient out and then enter the information into the EPR system? Another argument: *What if somebody breaks into your consulting rooms, hacks into your EPR system and reads confidential information in the patient records?* The defense: *What if somebody breaks into your consulting rooms, breaks open your filing cabinet and reads confidential information in the patient files?*

- **Identify the requirements, expectations, and needs regarding EPR systems as seen from the viewpoint of general practitioners in South Africa**

There *are* EPR systems on the market – mostly overseas systems. Why do South African general practitioners not acquire and use them? The most important reasons are that they might be inappropriate to the South African situation (e.g. different style of practice, different relationships to hospitals, specialists, pharmacists, or pathologists), they might be too expensive (the exchange rate has a major role to play in this issue!) and they might provide all the latest high-tech facilities where only a basic tool is needed. Often they might not be adaptable to a general practice

environment. Local products are still mostly in their development phases, and those that are available, are generally very expensive. In many of those products that do provide for EPR facilities, the EPR functions seem to be an after-thought in a mainly financial/administrative medical system.

The questionnaires therefore produced priceless results as far as requirements, expectations, and needs regarding EPR systems as seen from the viewpoint of general practitioners in South Africa was concerned.

- **Design and present prototype EPR systems for evaluation and testing by general practitioners in South Africa according to the requirements, expectations, and needs as mentioned above**

After determining that a need for an EPR existed, and that existing EPR programs do not satisfy the South African GP's needs and requirements, it was decided to commence with the development of a first EPR prototype system, based on the needs and requirements identified in the questionnaires. This prototype was evaluated and tested by general practitioners, as well as the designers. The results of the evaluation lead the way to the development of a second EPR prototype system.

- **Conduct a usability assessment of the above-mentioned prototype EPR systems**

An extensive usability assessment (evaluation) was performed on the two prototype EPR systems. According to these results the second prototype appeared to be a vast improvement on the first prototype – a definite step in the right direction towards the development of an EPR system for South African general practitioners.

- **Present the general practitioners of South Africa with a model of a proposed EPR system, designed for their specific requirements, expectations, and needs.**

The input and opinions of South African general practitioners were used throughout the prototype development process, firstly with questionnaires sent to them, and later with creating opportunities to evaluate the different prototypes. The result ... an EPR model that is believed to be acceptable by a major part of the general practitioner community in the country.

The model presents a system with a graphical-based user interface where the mouse and keyboard are used as input devices. Basic demographic information for families and patients are captured, while the clinical information is entered along the SOAP model. The system provides for different levels of access. Provision is made to view previous consultations. Queries regarding other patients may be conducted during a consultation, modifications in the form of "minutes" can be added to previous consultations and users may customise the system to provide them with choices in the system applicable to their own practices. Presently there are computer systems for medical billing, order/entry, laboratory systems, inventory management, communication, and pharmacy management. The medical note is the source from which all of the information used within these existing computerised medical systems is taken. Therefore the EPR model can be linked to any of the above-mentioned type of systems. Diagnosis and procedures can also be linked to existing coding structures. Communication channels with other role players in the Health Care industry, as well as with the patient, are possible via an email facility, while images like x-rays may be viewed and stored in the system. A scanning facility is also available to allow for, among others, the scanning of specialist reports. Physicians who do not have access to the electronic issuing of prescriptions via another medical program, are presented with limited dispensing functionality in that they may customise their systems to be able to choose from a list of medication available in their medicine cabinet. Invaluable research information may be obtained from an extended report generating facility.

From the above-mentioned it is therefore evident that all the goals that were set in Chapter 1, were met.

11.1.2 Additional contributions of this thesis

In addition to the presented model of an EPR system, this thesis made another important contribution. The evaluation methods used to evaluate the two prototypes may be applied

USABILITY PRINCIPLES	PROPOSED QUALITATIVE CRITERIA
Learnability	
Predictability	Do similar buttons (e.g. OK, Cancel) always yield the same results? Can the same actions be applied to similar components?
Synthesizability	Does the system indicate that a change occurred (e.g. successful save) by displaying appropriate messages?
Familiarity	Is the user interface familiar in terms of the user's task experience?
Generalizability	Could the user apply his/her knowledge of Windows to simplify the use of the new system?
Consistency	Is/Are the colour-use/screen layout/actions/components consistent throughout the system?
Interaction metaphors	Was it possible to relate the computer tasks to tasks in the real world?
Visual clarity	Did you perceive the screens as clear, well-organised, unambiguous, and easy to read?
User guidance and support	Does an on-line help facility exist? Are hints incorporated in the system? Are the labels descriptive?
Enjoyability	Did you enjoy using the system?
Conceptual (mental) models	Was it simple enough to form an accurate idea of what the system does and how it does it?
Flexibility	
Dialogue initiative	Did you have freedom of movement throughout the system?
Multi-threading	Could you perform more than one task at a time?
Task migratability	Did the system allow you to interfere during the performance of certain tasks?
Substitutivity	Could you use information displayed by the system as input to a following command?
Customizability	Was it possible to add your own choices to the lists displayed in combo boxes/list boxes?
Control	Did you feel in control of the system while using it?
Robustness	
Observability	Was it possible to browse through information of importance? Were defaults provided everywhere where it was needed? Was it easy/possible to reach all the options that you wanted to use? Did the system communicate effectively/provide adequate information?
Recoverability	Could you understand the error messages? Did the error messages recommend solutions to rectify the problem? Was it easy to return to the previous state after an error was made?
Responsiveness	Was the system's reaction to your commands fast enough?
WYSIWYG	Did your printed copies resemble the screens?
Task conformance	Was it easy/possible to perform your tasks on the system?

Table 11.1 Recommended criteria for qualitative evaluations

to similar projects in future. To put the valuable (and tested!) experience gained during the evaluation process to use, the following will be presented as guidelines for the evaluation of prototype-developed systems:

- Start the evaluation process by applying query techniques, for example the distribution of questionnaires, to the largest possible group of the potential user community. This will serve as a valuable starting point in assuring that, broadly seen, the project is on the right track (or the contrary!). This will also introduce the user community to the project and will prepare the way for establishing contacts with potential participants in future evaluation procedures.
- In addition to performing heuristic evaluations at specified intervals (pre-defined milestones) during the design process, much can be gained from performing heuristic evaluations on the completed system (or the completed prototype, if applicable). This will ensure that the user interface goals that were set during the design-phase heuristic evaluation, are in fact adhered to in the final system.
- When performing usability testing, both qualitative and quantitative measures should be applied. Both of these measures may be obtained from comparing the system under evaluation to the usability properties listed in Table 6.2.
- Qualitative evaluation may be performed by constructing criteria for each of the usability properties. These criteria may be presented to the users in the form of informal questions asked during, for example post-task walkthroughs. A recommended list of the qualitative criteria is presented in Table 11.1. (Although the qualitative evaluation performed for the purpose of this thesis was done in a less formal manner – and with great success – the perception is that the method just described will yield even better results).
- The quantitative evaluation may be performed on the basis of the criteria listed in Table 11.2. It is important to note that the association of criteria with the usability properties (in both Tables 11.1 and 11.2) is the author's own initiative. There might still be room for expansion of the lists, but they present a valuable point of departure.

USABILITY PRINCIPLES	PROPOSED QUANTITATIVE CRITERIA
Learnability	
Predictability	Number of times that the user asked for assistance Number of times that the user expressed frustration
Synthesizability	Number of times that a message appeared in the status bar
Familiarity	Number of times that the user asked for assistance
Generalizability	Number of times where ENTER was pressed in stead of TAB
Consistency	N/A
Interaction metaphors	N/A
Visual clarity	N/A
User guidance and support	Number of times that the user asked for assistance
Enjoyability	N/A
Conceptual (mental) models	N/A
Flexibility	
Dialogue initiative	Number of times that the user was prohibited from following a step/path
Multi-threading	Number of times where keyboard-use was attempted in vain
Task migratability	Number of times where the system asked for confirmation
Substitutivity	Number of times output on tables were used as input
Customizability	Number of times where the user would have preferred different options /values
Control	N/A
Robustness	
Observability	Number of static default values on the screen Number of dynamic default values on the screen Number of times that a message appears in the status bar
Recoverability	Time duration to make a correction Number of steps necessary to make a correction
Responsiveness	N/A
WYSIWYG	N/A
Task conformance	Time duration to create a consultation

Table 11.2 Recommended criteria for quantitative evaluations

- The conducting of a task analysis to test a system's task conformance (the association of a task analysis with task conformance also being the author's own initiative) forms an indispensable part of the evaluation process. It allows the designer to perceive the system at a much lower level than all the other methods. Most importantly, however, it places the designer "in the shoes of the user", viewing the system from the user's perspective. The interface is torn apart, so to speak, only to be put back together again, piece by piece, with amazing insight along the way!

- When gathering data for the purpose of the usability testing and subsequent task analysis, paper and pencil observational techniques may be carried out quite successfully, with the following pre-conditions:

  - The observational sessions should be planned thoroughly beforehand.
  - Care should be taken that no disruptions (phone calls, visitors, etc.) take place during the observations.
  - When recruiting the subjects to participate in the evaluations, they should be fully informed about the project, the purpose of the evaluation, what the evaluation sessions would entail, how long it would approximately take and their contribution and involvement in the project.
  - Before commencing with the observations, the tasks should be carefully explained to the subject. He/she must be re-assured that the system, and not he/she, is under scrutiny.
  - The sessions should not be too lengthy.
  - If one evaluator makes the observations, the specific criteria to be tested should be spread over a few tasks. This would enable the evaluator to keep up with the different aspects to measure, and will allow for more time-related criteria to be tested (one person handling more than one stopwatch at a time is bound to create chaos!).
  - Care should be taken in the design of the evaluation sheet (on which the measurements are transferred by the evaluator during the observations). It should facilitate ease of reading and use. The use of standard abbreviations on this sheet to compensate for slow writing-speed is highly recommended.
  - From experience, it would be suggested that at least two evaluators attend the observation sessions. This would serve as a counter-act for human error and more accurate results may be produced.

11.1.3 EPR model's right of existence

Why would general practitioners use an EPR system based on this presented model? Does the system stand any chance at all? The answers to these questions may be found in the following facts:

- In the research conducted on the status of the EPR in the rest of the world, lessons were learnt from the mistakes made in other countries that ventured on the path of creating an EPR system. This second-hand, but valuable experience was incorporated when the EPR model was designed.
- A paper on the methodology followed in this research project was accepted and subsequently presented at a Doctorate Consortium held in Aix-en-Provence, France, in June 1998. Positive feedback was received regarding the structured way in which the research was undertaken.
- A paper entitled "The Electronic Patient Record in General Practice – A South-African Perspective" was accepted for publication and presentation by the author at MedInfo '98 (the 9th World Congress on Medical Informatics) in Seoul, Korea in August 1998 [De Wet 1998]. This was the only South African paper accepted for presentation at the congress. Subsequently the paper was also indexed in the MEDLINE database (refer to Appendix O). It was gratifying to note that the research pertaining to this project compared favorably to similar projects in the rest of the world. The response received and interest shown after the presentation was overwhelming and served as an incentive to progress on the path originally taken.
- General practitioners themselves were involved in the design of the model. The research pertaining to the model was done from the ground level upwards – the South African general practitioners' requirements, needs, and preferences are reflected in the model. Their requirements were the building blocks of the model. It was not a case of a computer scientist view being forced on an EPR system. General practitioners were also heavily involved in the evaluation and testing of the prototypes on which the model was based. They are co-owners of the model,

so to speak. It is a South African model for South African circumstances – a first of its kind.

- Finally, the approaches being promoted by the present major players within the Health Care industry are simply not working. EPR systems are not acquired or used at present. This leaves a large opening for a small medical software developer to come up with an idea that will do it better and cheaper, with the requirements of physicians as main goal. This might put well-established firms in jeopardy, while giving a system along the lines of the EPR model the edge.

11.2 Future developments

When considering what lies ahead for this research project, the future seems bright and rosy! The EPR model presented in this thesis has laid the foundation for any prospective designer/developer of medical software packages to design an EPR system. These designers will have the re-assurance that the system constitutes the needs, requirements, and preferences of many South African general practitioners. The normal procedures regarding evaluating (including observational studies in general practice), testing, marketing, installation, and maintenance of the program should then be followed.

Issues regarding the EPR where research is still required, include standards, ethics, privacy, security, legal aspects, and communication between the EPR, the different Health Care roll players and existing medical computer systems. This is true worldwide. In South Africa a first step has been taken regarding standards with the establishment of a subcommittee which will be responsible for all national standardization in the field of Health Care Informatics. All the above-mentioned aspects become particularly important when considering the idea of presenting an EPR system via the Internet. The "Internet" and "Web-page systems" are the buzz words of the nineties and will sooner or later require serious consideration.

From a physician's point of view, the ideal EPR computer system would be like the "tri-corder" used in the television series Star Trek. The "tri-corder" is a gadget that is

portrayed as being able to determine the morphology and physiology of a particular patient, gather and analyze the data, and consequently generate a report [Naegele1995]. Scientific technology is not there yet. Until this futuristic vision becomes a reality, man has to deal with the computers of our time – tools that can only do what man can do. They simply do it much faster and more efficiently, as has been illustrated with the concept of the electronic patient record in this thesis.

Appendix A

Cover letter and Questionnaire

Tel: (051) 401-2583
2 January 1997

Dear Doctor

The enclosed questionnaire forms part of a research project jointly undertaken by the Department of Computer Science and Informatics and the Department of Family Medicine at the University of the Free State, concerning the *electronic patient record.* More specifically, it also forms part of the research pertaining to my doctoral degree in this field.

From all the practising general practitioners in the Free State, a random sample has been drawn and you form part of the selected respondents. It would be appreciated if you could spare some time to answer the questionnaire and return it to me in the enclosed self-addressed envelope before **31 January 1997.** If you are not practising as a general practitioner at present, you need only answer the first question on the questionnaire (1.1) before returning it.

Please be assured that your completed questionnaire will be dealt with confidentially and anonymously. Please, therefore, feel free to answer with complete openness and in detail, as thoroughly completed questionnaires will also greatly simplify our task. You will note that a certain number has been affixed to the upper, right hand corner of the first page. For administrative purposes, a number will be allocated to every questionnaire so that a record may be kept of them as they are returned.

Any queries can be directed to me at the above-mentioned address or telephone number, or I may be contacted at home at telephone number (051) 446-3735.

Thank you in anticipation for your willingness to complete the questionnaire. In so doing, you will undoubtedly also be contributing towards reaching a step closer to the "ideal" computer-based patient record.

Kind regards.

LIZETTE DE WET (MRS)

QUESTIONNAIRE TO GENERAL PRACTITIONERS

FOR OFFICIAL USE

☐☐☐ 1-3

***All the respondents must complete Sections A, B, C and D. Indicate your choice by means of an* X.**

SECTION A

1.1. Which of the following applies to you at present?

Practise as a general practitioner	
Retired general practitioner	
Busy specialising	
Other (specify)	

☐ 4

*If you are **not** practising as a general practitioner at present, we would appreciate it if you would stop completing the questionnaire, place it in the included envelope and return it to us promptly. Thank you very much for your willingness to complete the questionnaire.*

1.2. What is the nature of the practice in which you are engaged?

One-man practice	
Partnership/association	

☐ 5

1.3. How long (number of years) have you been in private practice?

☐☐ 6-7

SECTION B

2.1. Is a computer used in your practice?

YES		NO	

☐ 8

If your answer to Question 2.1 is 'YES', answer Questions 2.2 to 2.5. If your answer to Question 2.1 is 'NO', go to Section C.

2.2. For which purpose is the computer currently used in your practice? *(You may select more than one option.)*

Administrative	
Clinical	
Other (specify)	

☐ 9
☐ 10
☐ 11
☐ 12

2.3. Which medical commercial computer system(s) is/are currently in use in your practice?

☐☐ 13-14
☐☐ 15-16
☐☐ 17-18

2.4. Are you satisfied with the system(s) currently in use? ☐ 19

YES		NO		*If 'NO', please state reasons:*

_____ ☐☐ 20-21

_____ ☐☐ 22-23

_____ ☐☐ 24-25

2.5. Who uses your computer system at present? *(You may select more than one option.)*

Practitioner		☐ 26
Receptionist		☐ 27
Clerical personnel		☐ 28
Accountant		☐ 29
Other (specify)		☐ 30
		☐ 31

SECTION C

3. Manual system

3.1. Do you have a written task description/explanation of the clinical record system (manual system) you are using at present?

YES		NO	

☐ 32

3.2. Of which "components" does the clinical record system (manual system) you are currently using, consist? *(You may select more than one option.)*

File folder per patient		☐ 33
File folder per household with individual family members' records inside		☐ 34
Clinical record card		☐ 35
Problem list		☐ 36
Prescription book only for prescriptions		☐ 37
Prescription book for prescriptions, house calls, hospital visits, operations		☐ 38
Certificate of absence		☐ 39
Card with patient reference number		☐ 40
Cross referencing card (numerical reference numbers used)		☐ 41
Specialist reports		☐ 42
Laboratory reports		☐ 43
Other (specify)		☐ 44
		☐ 45

3.3. Which scheme do you use to record the clinical information?

SOAP-scheme (Subjective, Objective, Assessment, Plan)	☐ 46
Other (specify)	

3.4. Which framework/scheme do you use for recording the systemic details (physical examination)?

From head to toes, e.g. begin with the *psyche* and end with the *blood and reticulo-endothelial* system.	
Other (specify)	

☐ 47

3.5. Which of the following usually applies to you when you record the clinical information of the patient?

Notes are made in the presence of the patient	
Notes are made as soon as the patient leaves the consulting rooms	
Notes are made at the end of each day	
Notes are made partly in the presence of the patient and partly as soon as he/she has left the room	
Other (specify)	

☐ 48

3.6. Approximately how long (in seconds) does it take you to perform the following tasks while using your existing manual system?

Find a patient record	
File a patient record	

☐☐☐ 49-51
☐☐☐ 52-54

3.7. Which of the following problems do you experience with your current clinical record system (manual system)? *(You may select more than one option.)*

Time consuming	
Lost files	
Mis-filed files	
Recording of external work (house calls, hospital calls, operations)	
Separate clinical and financial systems	
Unpractical format	
Durableness of records	
Transferability of records (Patient changes to a different practitioner)	
Identifying old, unused records	
Immediate recording of the patient's visit	
Filing reports/x-rays	
Delays in handling specialist/lab reports	
Duplication	
Incompleteness of medical record as a whole	
Not adaptable to changing circumstances	
Illegible/incomprehensible	
None	
Other (specify)	

☐ 55
☐ 56
☐ 57
☐ 58
☐ 59
☐ 60
☐ 61
☐ 62
☐ 63
☐ 64
☐ 65
☐ 66
☐ 67
☐ 68
☐ 69
☐ 70
☐ 71
☐ 72
☐ 73

3.8. Indicate for which of the following additional purposes you are able to use your existing clinical records (manual system). *(You may select more than one option.)*

Draw statistics for personal information and for the sake of interest		1
Research regarding general practitioning		2
Reminders of follow-up visits		3
Opportunistic prevention e.g. to prevent epidemics		4
Determining of health risks e.g. to determine a patient's chances of having a heart attack		5
None		6
Other (specify)		7
		8

SECTION D

4. Use of the computer system

4.1. If you should change to a computerised clinical record system, would you still prefer to have a printed copy of the patient's record?

YES		NO	

Please give reasons for your answer. 9

_____ 10-11

_____ 12-13

_____ 14-15

4.2. Please indicate your attitude towards the use of a computer in the presence of the patient during the examination.

Totally negative		Moderately negative		Neutral		Moderately positive		Totally positive	

16

Please give reasons for your answer.

_____ 17-18

_____ 19-20

_____ 21-22

4.3 In which of the following instances do you feel the computer can be used in the presence of the patient? *(You may select more than one option.)*

Administrative/Financial		23
Call up a patient's medical history		24
As part of the clinical examination		25
Dispensing		26
Statistical/Graphical information		27
Other (specify)		28
		29

4.4. Should recording of the clinical information take place in the presence of the patient, which of the following methods would you prefer for entering information into the computer? *(You may select more than one option.)*

Typing, using the keyboard		30
Mouse		31
Light pen (pen-size type of bar code scanner)		32
Speech		33
Touch screen		34
Other (specify)		35
		36

4.5. If you were to use a computer system during the clinical examination, which ***one*** of the following things would you prefer to do:

Enter the information immediately in the presence of the patient.		37
Make notes which you will enter into the computer yourself later on.		
Make notes which the receptionist/clerical personnel can enter later on.		
Other (specify)		

4.6. If you should use the computer as part of the clinical examination, for which of the following purposes would you prefer to use the system, the results and the output? *(You may select more than one option.)*

Organised computerised text-based patient records		38
Images e.g. photograph of patient, x-rays		39
Statistical information/graphics regarding individual patients/all patients		40
Information for planning purposes		41
Information for research purposes		42
Prescriptions		43
Access to external (health services) databases		44
Other (specify)		45
		46

4.7. With which of the following parties would you like to establish contact through the system? *(You may select more than one option.)*

Other general practitioners		47
Other specialists		48
Pharmacies		49
Radiologists		50
Hospitals		51
Pathologists		52
Laboratories		53
Medical funds		54
None of the above		55
Other (specify)		56

4.8. Are you in favour of a guideline-based computerised patient record system, i.e. a system based on systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances?

YES		NO	

☐ 57

5. Problems with/objections against computer-based patient records

5.1. Which practical problems do you foresee regarding the use/functioning of a computerised clinical record system? (*You may select more than one option.)*

Recording of work performed outside the consulting room		58
Relationship of trust with the patient		59
Immediate recording of a visit		60
Process of change from a manual system		61
Resistance on the part of patients		62
Resistance on the part of personnel		63
Lack of general standards regarding : - standard clinical vocabulary		64
- patient identification		65
Problems in linking information (e.g. hand-written reports) with the system		66
Computer tasks interfering with existing normal tasks		67
Changed working method		68
Not adaptable to changing circumstances		69
Other (specify)		70
		71

5.2 Indicate which problems you foresee with/objections you have against computer-based patient records in general practice? (*You may select more than one option.)*

Ethics		1
Security		2
Hardware		3
Software		4
Personnel		5
Time- Training		6
- Use of the system		7
- Duration of patient encounter		8
Cost- Initial capital investment		9
- Operating cost		10
Computer illiteracy		11
Quality of information		12
Other (specify)		13
		14

6 General

6.1 In your opinion, to which of the following fields should professional societies contribute? (*You may select more than one option.)*

Provision of guidelines for information systems in general practice		15
Evaluation of existing computer systems		16
Training of general practitioners in the use of information systems		17
Negotiating partial compensation for system implementation with government		18
Other (specify)		19
		20

6.2 Would you like to use the INTERNET?

YES		NO		

Please give reasons for your answer. 21

_____ 22-23
_____ 24-25
_____ 26-27

6.3. Are you of the opinion that a computerised patient record system can be successful?

YES		NO		

Please give reasons for your answer. 28

_____ 29-30
_____ 31-32
_____ 33-34

6.4. If a good computerised patient record system were to be available, would you use it?

YES		NO		

If 'NO', please state reasons. 35

_____ 36-37
_____ 38-39
_____ 40-41

6.5. Would you be prepared to assist in this project again in future?

YES		NO		

42

6.6. If you are not using a computer in your practice at the moment, would you like to use one in your practice in future?

YES		NO		N.A.	

If 'NO', please state reasons. 43

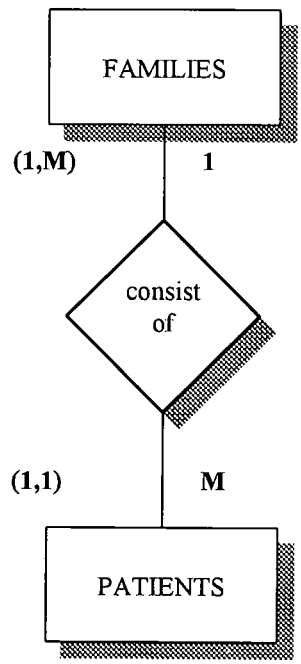
_____ 44-45
_____ 46-47
_____ 48-49

50-51

Appendix B

Detail relationships among entities for the first prototype

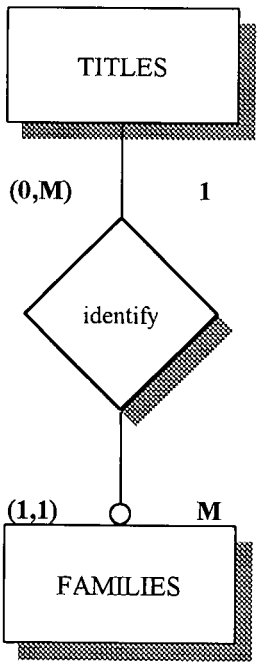
- **FAMILIES and PATIENTS**



A family may consist of one or many patients.

A patient may belong to only one family.

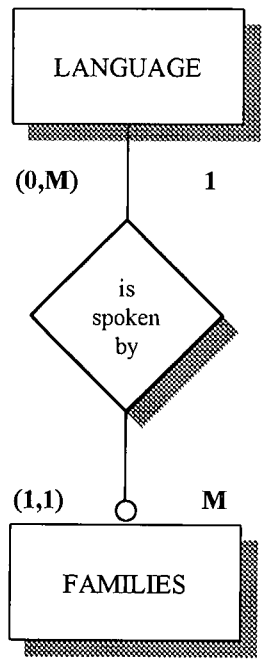
- **TITLES and FAMILIES**



A title can be allocated to none or many families. Therefore FAMILIES is optional to TITLES.

A family must have a title.

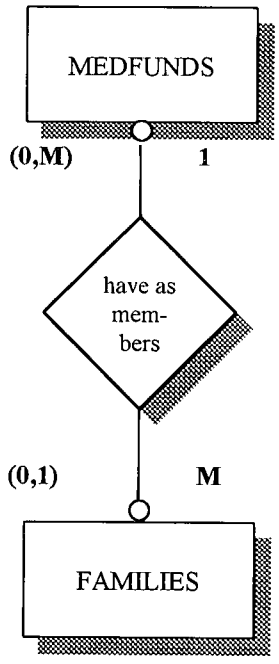
- **LANGUAGE and FAMILIES**



A home language can be spoken by none, or many families. Therefore FAMILIES is optional to LANGUAGE.

A family speaks one home language.

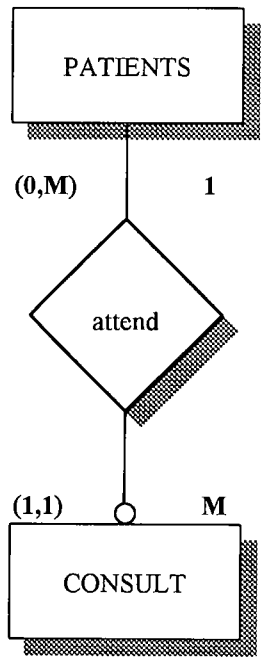
- **MEDFUNDS and FAMILIES**



Medical Funds may have none or many families as members. Therefore FAMILIES is optional to MEDFUNDS.

A family may or may not be a member of a medical fund. Therefore MEDFUNDS is optional to FAMILIES.

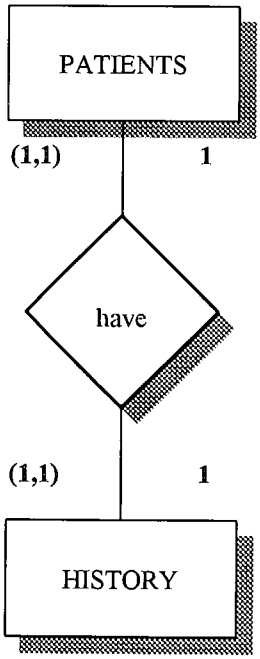
- **PATIENTS and CONSULT**



A patient may attend none or many consultations. Therefore CONSULT is optional to PATIENTS.

A specific consultation is attended by only one patient.

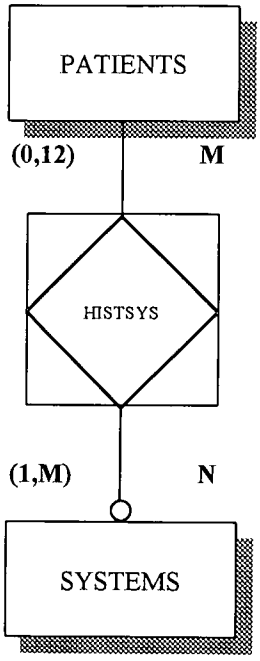
- **PATIENTS and HISTORY**



A patient has only one history record.

A history record may belong to only one patient.

- **PATIENTS and SYSTEMS (HistSys)**

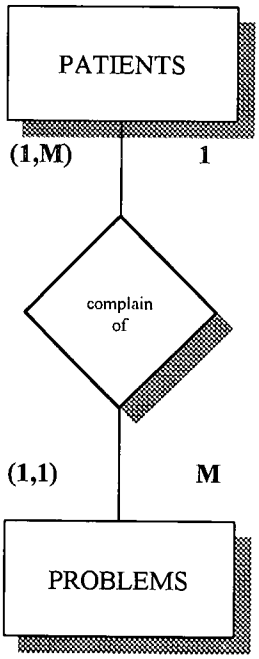


A patient may have information on none or 12 systems. Therefore SYSTEMS is optional for PATIENTS.

HISTSYS is a composite entity.

A system may be associated with one or more patients.

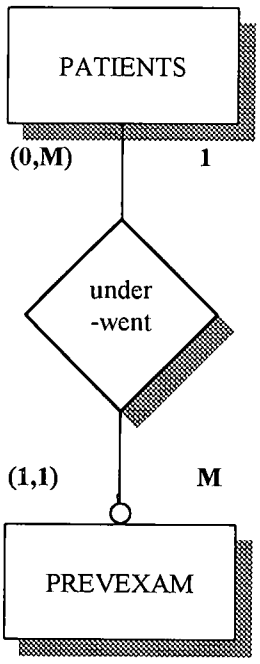
- **PATIENTS and PROBLEMS**



A patient can complain of many problems.

A specific problem may belong to only one patient.

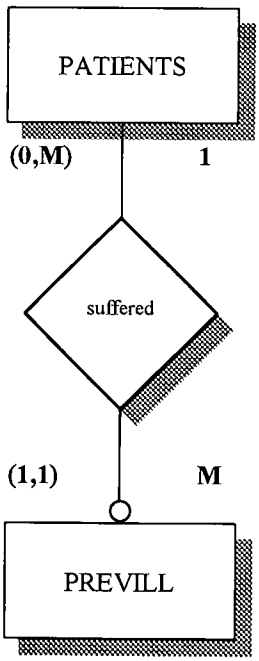
- **PATIENTS and PREVEXAM**



A patient underwent none or many previous investigations. Therefore PREVEXAM is optional to PATIENTS.

A previous investigation may done to only one patient.

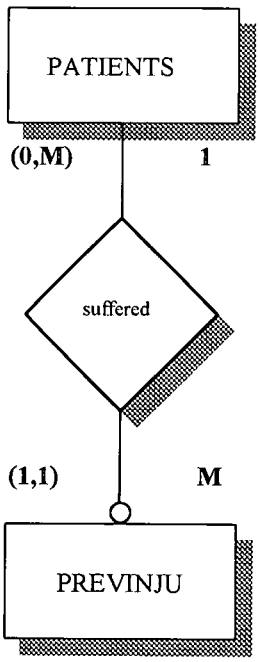
- **PATIENTS and PREVILL**



A patient may have suffered from none or many previous illnesses. Therefore PREVILL is dependent on PATIENTS.

A previous illness may be suffered by only one patient.

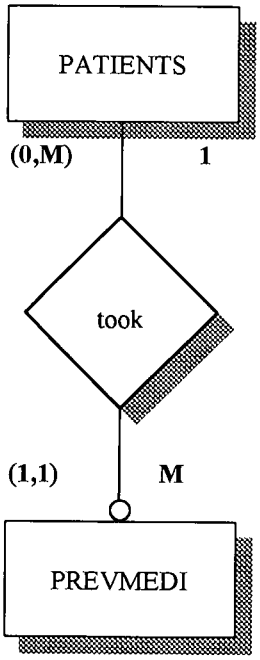
- **PATIENTS and PREVINJU**



A patient may have suffered from none or many previous injuries. Therefore PREVINJU is dependent on PATIENTS.

A previous injury may have been suffered by only one patient.

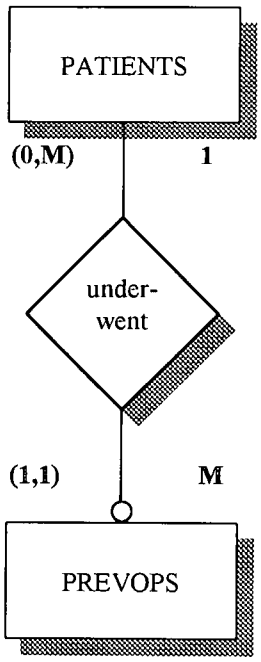
- **PATIENTS and PREVMEDI**



A patient may have taken none ar many different kinds of medication. Therefore PREVMEDI is dependent on PATIENTS.

A specific previous medication may only have been taken by one patient.

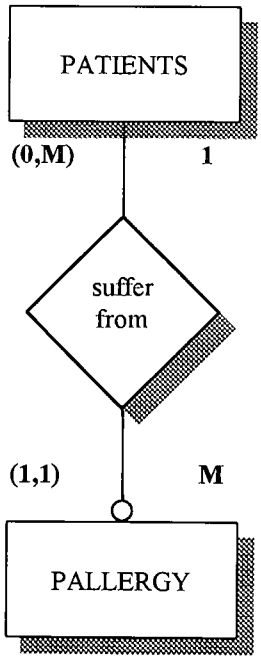
- **PATIENTS and PREVOPS**



A patient may have had none or many previous operations. Therefore PREVOPS is dependent on PATIENTS.

A specific previous operation may only have been done to one patient.

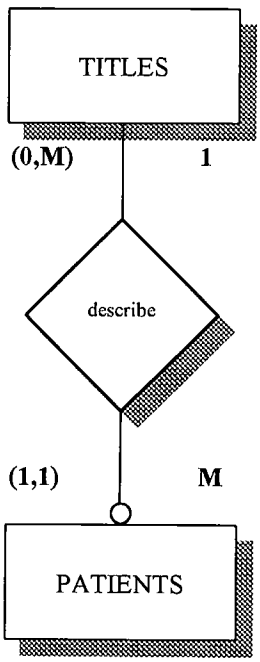
- **PATIENTS and PALLERGY**



A patient suffers from none or many allergies. Therefore PALLERGY is dependent on PATIENTS.

A specific allergy may be suffered from by only one patient.

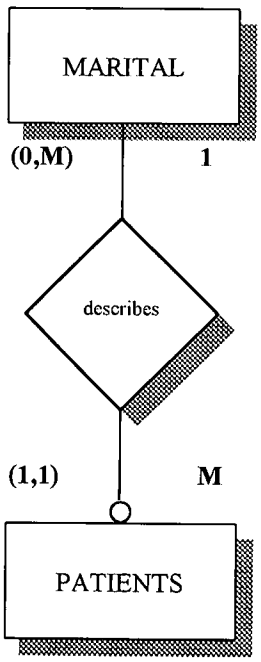
- **TITLES and PATIENTS**



A title may describe none or many patients. Therefore PATIENS is optional to TITLES.

A patient may be described by only one title.

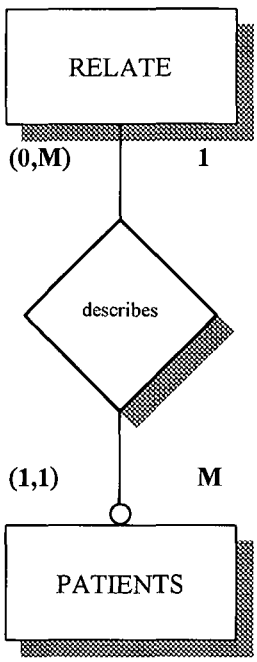
- **MARITAL and PATIENTS**



A marital state may describe none or many patients. Therefore PATIENTS is optional to MARITAL.

A patient may be described by only one marital state.

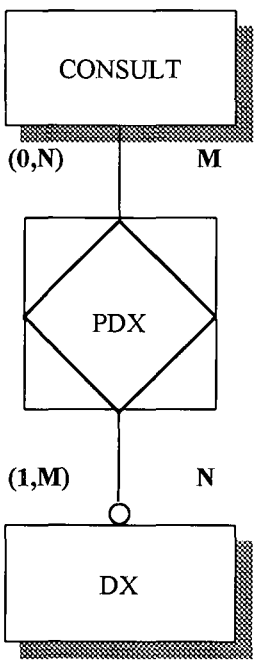
- **RELATE and PATIENTS**



A relationship may describe none or many patients. Therefore PATIENTS is optional to RELATE.

A patient may be described by only one relationship.

- **CONSULT and Dx (PDx)**

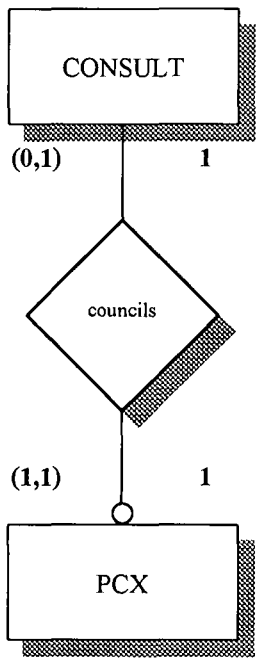


A consultation may cause a patient to undergo none or many Dx examinations. Therefore DX is dependent on CONSULT.

PDX is a composite entity.

A Dx may have been undergone by one or many patients at one or many consultations.

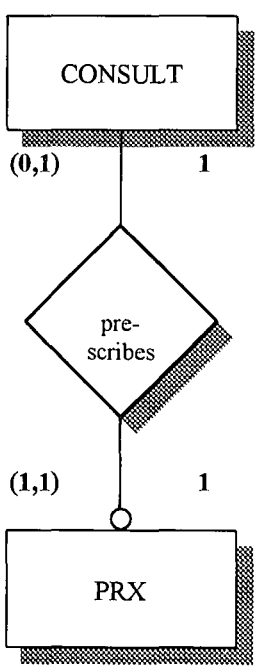
- **CONSULT and PCX**



During a consultation, a patient may have none or one Cx (counselling) record.

A specific Cx counselling record may belong to only one consultation.

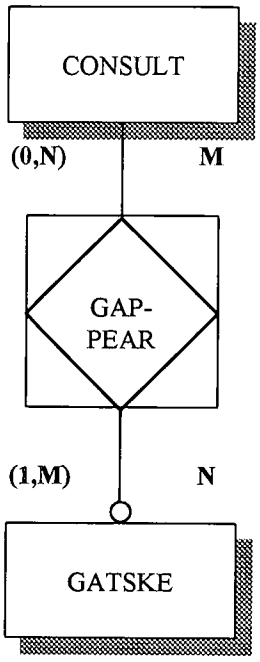
- **CONSULT and PRX**



For a consultation, a patient may have none or one Rx (prescription) record. Therefore PRX is dependent on CONSULT.

A specific Rx (prescription) record may belong to only one consultation.

- **CONSULT and GATSKE**

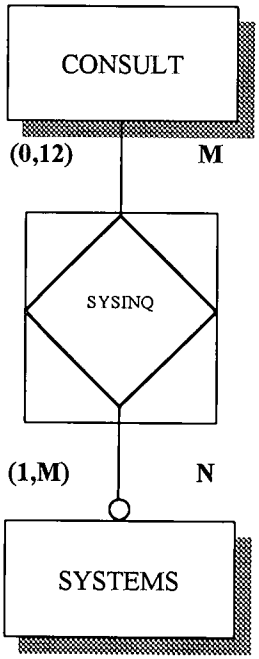


A specific consultation may be associated with none or many states (e.g. Jaundice, Glands, Clubbing of fingers), being abbreviated by the term GATSKE. Therefore GATSKE is dependent on CONSULT.

GAPPEAR is a composite entity.

A specific state may be associated with many consultations.

- **CONSULT and SYSTEMS (SysInq)**

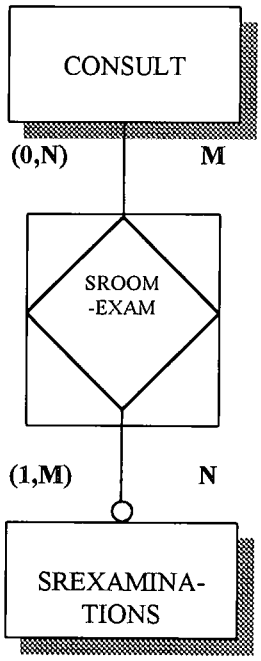


For a specific consultation a patient may be associated with none or up to 12 of the body systems. Therefore SYSTEMS is dependent on CONSULT.

SYSINQ is a composite entity.

A system may be associated with many consultations.

- **CONSULT and SREXAMINATINS (SRoomExam)**

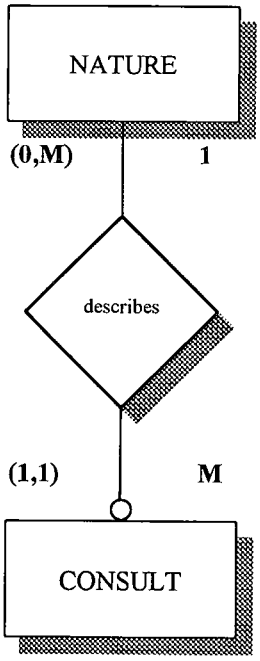


For a specific consultation, none or many sideroom investigations can be done on the patient. Therefore SREXAMINATIONS is dependent on CONSULT.

SROOMEXAM is a composite entity.

A specific sideroom investigation can be performed on many patients during many consultations.

- **CONSULT and NATURE**



A specific type of consultation may be associated with none or many consultations. Therefore CONSULT si dependent on NATURE.

A specific consultation may only be associated with one type of consultation (e.g. house-call, operation).

Appendix C

Attributes for the entities of the first prototype

Entity: DX

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
Dx_DxId	Diagnostic measures identification	PK, FK to DX
Dx_Dx	Diagnostic measures description, e.g. E.C.G. investigation	

Entity: FAMILIES

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
Fam_AccountId	Family account identification number	PK
T_TitleId	Title identification number	FK to TITLES
Fam_Initials	Family-head initials	
Fam_Surname	Family surname	
Fam_PostalAddress1	Family-head postal address	
Fam_PostalAddress2		
Fam_PostalAddress3		
Fam_PostalAddress4		
Fam_PostalCode	Postal code	
Fam_TelHome	Family-head home phone number	
Fam_TelWork	Family-head work phone number	
Fam_Cell	Family-head cellular number	
Fam_Fax	Family-head fax number	
Mf_MedFundId	Family medical fund identification nr	FK to MEDFUNDS
Fam_MedFundNo	Medical fund membership number	
L_LanguageId	Language identification number	FK to LANGUAGE
Fam_CurrEmp	Family-head's current employer	
Fam_CurrEmpAddress	Address of current employer	
Fam_PrevEmp	Family-head's previous employer	
Fam_PrevEmpAddress	Address of previous employer	
Fam_PrevDoc	Family-head's previous doctor	
Fam_PrevDocAddress	Address of previous doctor	
Fam_Remarks	Remarks on the family	

Entity: GAPPEAR

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Con_ConsultId	Consultation identification number	PK
Ga_GatskeId	Category of general appearance identification number	FK to GATSKE
Ga_GatskeRemarks	Remarks on specific category	

Entity: GATSKE

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
Ga_GatskeId	Category of general appearance identification number	PK
Ga_Gatske	Description of category	

Entity: HISTORY

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Hist_FamHist	Family history of patient	
Hist_GenProfile	General profile of patient	

Entity: HISTSYS

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Sys_SystemId	System identification number	FK to SYSTEMS
Hsys_Remarks	Remarks per system per patient	

Entity: LANGUAGE

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
L_LanguageId	Home language identification number	PK
L_Language	Home language description	

Entity: MARITAL

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
M_MaritalId	Marital state identification number	PK
M_Marital	Marital state description	

Entity: MEDFUNDS

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
Mf_MedFundId	Medical funds identification number	PK
Mf_MedFund	Medical fund name	

Entity: NATURE

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
Nat_NatureId	Type of consultation identification number	PK
Nat_Nature	Description of type of consultation	

Entity: PALLERGY

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Pal_AllergyNr	Automatic numbering of allergies per patient	PK
Pal_Allergy	Allergy description	
Pal_DateSince	Date since patient has had the allergy	
Pal_Note	Notes on the allergy	

Entity: PATIENTS

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Fam_AccountId	Family account identification number	FK to FAMILIES
T_TitleId	Patient title identification number	FK to TITLES
P_Initials	Patient initials	
P_Surname	Patient surname	
P_FirstName	Patient first names	
P_IdNo	Patient identification number	
P_DOB	Patient date of birth	
P_Gender	Patient gender (Male/Female)	
P_HomeAddress1	Patient residential address	
P_HomeAddress2		
P_HomeAddress3		
P_Occupation	Description of patient's occupation	
P_MaritalId	Patient marital state identification number	FK to MARITAL
P_Church	Patient church denomination	
P_School	School that patient attends/attended	
Rel_RelationshipId	Patient's relationship with family-head (identification number)	FK to RELATE
P_Remarks	Remarks on patient	

Entity: PCX

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Con_ConsultId	Consultation identification number	
Pcx_Cx	Patient counselling/information	

Entity: PDX

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Con_ConsultId	Consultation identification number	PK
Dx_DxId	Diagnostic measures identification	FK to DX

Entity: PREVEXAM

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Pe_ExaminationNr	Automatic numbering of previous investigations per patient	PK
Pe_Examination	Description of previous investigation	
Pe_Date	Date that previous investigation took place	
Pe_Results	Results of previous investigation	
Pe_Note	Notes on previous investigation	

Entity: PREVILL

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
Pi_IllnessNr	Automatic numbering of previous illnesses per patient	PK
P_PatientId	Patient identification number	PK
Pi_Illness	Description of previous illness	
Pi_Date	Date on which previous illness occurred	
Pi_Note	Notes on previous illness	

Entity: PREVINJU

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Pin_InjuryNr	Automatic numbering of previous injuries per patient	PK
Pin_Injury	Description of previous injury	
Pin_Date	Date on which previous injury took place	
Pin_Note	Notes on previous injury	

Entity: PREVMEDI

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Pm_MedicineNr	Automatic numbering of previously taken medication per patient	PK
Pm_Medicine	Description of previous medication	
Pm_Date	Date when medication was taken	
Pm_Note	Notes on previous medication	

Entity: PREVOPS

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Po_OperationNr	Automatic numbering of previous operations per patient	PK
Po_Operation	Description of previous operation	
Po_Date	Date on which previous operation was done	
Po_Note	Notes on previous operation	

Entity: PROBLEMS

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Pr_ProblemNr	Automatic numbering of problems per patient	PK
Pr_Problem	Description of the patient's problem	
Pr_ProblemDateTime	Date in which problem occurs	
Pr_Outcome	Description of the outcome of the problem	
Pr_OutcomeDateTime	Date on which the outcome occurs	

Entity: PRX

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Con_ConsultId	Consultation identification number	PK
Prx_Rx	Therapeutic measures	

Entity: RELATE

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
Rel_RelationshipId	Identification number of type of relationship between patient and family-head	PK
Rel_Relationship	Description of relationship between patient and family-head	

Entity: SREXAMINATIONS

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
Srex_ExaminationId	Identification number of type of sideroom examination	PK
Srex_Examination	Description of sideroom examination	

Entity: SROOMEXAM

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Con_ConsultId	Consultation identification number	PK
Srex_ExaminationId	Identification number of type of sideroom examination	PK, FK to SREXAMINATIONS
Sroomex_Remarks	Remarks on sideroom examination	

Entity: SYSINQ

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Con_ConsultId	Consultation identification number	PK
Sys_SystemId	System identification number	PK,FK to SYSTEMS
Sysinq_Remarks	Remarks per system per patient	

Entity: SYSTEMS

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
Sys_SystemId	Body system identification number	PK
Sys_System	Description of system	

Entity: TITLES

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
T_TitleId	Title identification number	PK
T_Title	Title description	

Appendix D

Sample data for the entities of the first prototype

Sample data of entity DX

Dx_DxId	Dx_Dx
3	Sonar of the gall bladder showed gall stones.
1	Chest x-ray normal

Sample data for entity FAMILIES

Fam_AccountId	T_TitleId	Fam_Initials	Fam_Surname	Fam_PostalAddress1
F1	1	CF	JORDAAN	P O Box 1356
F14	3	Z	ROODE	Veronica Flats 13

Fam_PostalAddress2	Fam_PostalAddress3	Fam_PostalAddress4	Fam_PostalCode
Universitas	Bloemfontein		9321
145 Church Street	Pretoria		0002

Fam_TelHome	Fam_TelWork	Fam_Cell	Fam_Fax	Mf_MedFundId
(051)446-1234	(051)444-1598	0836542445	(051)444-1211	1
(012)807-4587	(012)524-8758	0824578987	(051)524-8758	2

Fam_MedFundNo	L_Language	Fam_CurrEmp	Fam_CurrEmpAddress	Fam_PrevEmp
1234567	1	ABSA	Brandwag, Bloemfontein	Standard
987-452-8	2	Gouws & Kie	Church Street, Pta	Student

Fam_PrevEmpAddress	Fam_PrevDoc	Fam_PrevDocAddress	Fam_Remarks
Brandwag, Bloemfontein	Dr. Steyn	Centurion	Lost job recently
UP	Dr Bernett	UP Campus	

Sample data for entity GAPPEAR

P_PatientId	Con_ConsultId	Ga_GatskeId	Ga_GatskeRemarks
P1	1	AN	Anaemia – tire easily, white skin, bruises
P7	12	JA	Jaundice as child

Sample data for entity GATSKE

Ga_GatskeId	Ga_Gatske
AE	Oedema
AN	Anaemia
CL	Clubbing of Fingers
CY	Cyanosis
GE	General
GL	Glands
JA	Jaundice

Sample data for entity HISTORY

P_PatientId	Hist_FamHist	Hist_GenProfile
P1	Father died (45), Mother died(55)	Smokes 40 sigs/day
P34	Parents both alive; 3 healthy children	Appears healthy

Sample data for entity HISTSYS

P_PatientId	Sys_SystemId	Hsys_Remarks
P4	1	Nervous breakdown in 1988. Hospitilised for 2 weeks.
P4	3	Double vision when driving or concentrating on objects.

Sample data for entity LANGUAGE

L_LanguageId	L_Language
1	Afrikaans
2	English

Sample data for entity MARITAL

M_MaritalId	M_Marital
1	Married
2	Single

Sample data for entity MEDFUNDS

Mf_MedFundId	Mf_MedFund
1	Medihelp
2	Visimed

Sample data for entity NATURE

Nat_NatureId	Nat_Nature
1	Consultation
2	House call

Sample data for entity PALLERGY

P_PatientId	Pal_AllergyNr	Pal_Allergy	Pal_DateSince	Pal_Note
P1	1	Penissilien	1965	Since birth
P1	2	Bee sting	1998	Stung while cycling

Sample data for entity PATIENTS

P_PatientId	Fam_AccountId	T_TitleId	P_Initials	P_Surname
P5	F3	1	LG	Le Roux
P18	F12	3	L	Wessels

P_FirstName	P_IdNo	P_DOB	P_Gender	P_HomeAddress1
Louis Gert	6405142258114	1964/05/14	M	14 Lily Street
Lina	9704120054885	1997/04/12	F	225 Van Wyk Street

P_HomeAddress2	P_HomeAddress3	P_Occupation	P_MaritalId	P_Church
Alberton		Engineer	1	Dutch Reform
Newlands	Cape Town	Accountant	2	NA

P_School	Rel_RelationshipId	P_Remarks
Linden	1	Happy family
Constantia	2	Going through difficult depression

Sample data for entity PCX

P_PatientId	Con_ConsultId	Pcx_Cx
P9	12	Discussed diet for obesity.
P14	2	Recommend: cut down on smoking, coffee

Sample data for entity PDX

P_PatientId	Con_ConsultId	Dx_DxId
P3	1	1
P5	3	4

Sample data for entity PREVEXAM

P_PatientId	Pe_ExaminationNr	Pe_Examination	Pe_Date	Pe_Results	Pe_Note
P4	1	X-ray	1988	Neg.	
P4	2	Abdominal sonar	1975	Positive	Ulcer

Sample data for entity PREVILL

Pi_IllnessNr	P_PatientId	Pi_Illness	Pi_Date	Pi_Note
1	P2	Chickenpox	1993	Age 28 - severe
2	P2	Mumps	1995	Hospitilised

Sample data for entity PREVINJU

P_PatientId	Pin_InjuryNr	Pin_Injury	Pin_Date	Pin_Note
P4	1	Torn ligament	1989	Left
P4	2	Knee-cap	1994	Physiotherapy

Sample data for entity PREVMEDI

P_PatientId	Pm_MedicineNr	Pm_Medicine	Pm_Date	Pm_Note
P8	1	Disprin	1996	Discontinued
P8	2	Panado	1997	

Sample data for entity PREVOPS

P_PatientId	Pin_OperationNr	Pin_Operation	Pin_Date	Pin_Note
P89	1	Torn ligament	1988	Left
P89	2	Bypass	1997	3 vanes

Sample data for entity PROBLEMS

P_PatientId	Pr_ProblemNr	Pr_Problem	Pr_Problem DateTime	Pr_Outcome	Pr_Outcome DateTime
P6	4	Always tired	1999/01/01		
P6	5	Head-aches	1999/01/01		

Sample data for entity PRX

P_PatientId	Con_ConsultId	Prx_Rx
P4	2	Tabs Antacid 30 Tds a.c.
P15	14	Supps Candikill 10 PV bd

Sample data for entity RELATE

Rel_RelationshipId	Rel_Relationship
2	Wife
3	Child

Sample data for entity SREXAMINATIONS

Srex_ExaminationId	Srex_Examination
1	ECG
2	Hemoglobin

Sample data for entity SROOMEXAM

P_PatientId	Con_ConsultId	Srex_ExaminationId	Sroomex_Remarks
P54	13	2	Results 8 gm/dl
P33	2	1	Few premature atrial contractions

Sample data for entity SYSINQ

P_PatientId	Con_ConsultId	Sys_SystemId	Sysinq_Remarks
P12	3	6	Creps both lung bases
P14	2	13	Signs of anaemia

Sample data for entity SYSTEMS

Sys_SystemId	Sys_System
1	Psyche
2	Central Nervous System
3	Eyes
4	Ear, nose & throat
5	Cardiovascular
6	Respiratory
7	Breasts
8	Gastro-intestinal
9	Uro-genital
10	Musculo-skeletal
11	Ectoderm
12	Endocrine
13	Blood and RE system

Sample data for entity TITLES

T_TitleId	T_Title
1	Mr
2	Mrs

Appendix E

Evaluation form used during evaluation of first prototype

ELEKTRONIESE PASIëNT REKORD PROTOTIPE /
ELECTRONIC PATIENT RECORD PROTOTYPE

EVALUASIE / *EVALUATION*
16 MEI / *MAY* 1998

Naam/*Name* : _____

Adres/*Address* : _____

_____

_____

Tel.Nr. : _____

E-pos/*E-mail* : _____

(Die voltooiing van bogenoemde inlingting is opsioneel / *The completion of the information above is optional.*)

Beoordeel hierdie sagteware prototipe in terme van die volgende deur u keuse met 'n X op die toepaslike nommer aan te dui:
Please rate this software prototype in terms of the following, indicating your choice with an X on the appropriate number :

(1=bestaan nie, 2=swak, 3=redelik, 4=goed, 5=uitstekend)
(1=non-existent, 2=poor, 3=fair, 4=good, 5=excellent)

1. Die taak om 'n nuwe familie te registreer, is maklik.
   The task to register a new family is easy. 1 2 3 4 5

2. Daar bestaan gerieflike metodes om 'n familie op te spoor.
   There are convenient means to search for a family. 1 2 3 4 5

3. Die taak om 'n nuwe pasiënt te registreer, is maklik.
   The task to register a new patient is easy. 1 2 3 4 5

4. Daar bestaan gerieflike metodes om 'n pasiënt op te spoor.
There are convenient means to search for a patient. 1 2 3 4 5

5. Die stelsel maak voorsiening vir al die algemene praktisyn se basiese kliniese dienste.
The system provides for all the basic general practitioner clinical services. 1 2 3 4 5

6. Die stelsel stem baie ooreen met die ou manier van dinge doen.
The system corresponds closely to the old way of doing things. 1 2 3 4 5

7. Die stelsel verseker, waar moontlik, dat die data wat ingevoer word, geldig is.
The system ensures that the entered data is valid to the extent possible. 1 2 3 4 5

8. Die stelsel voorsien my van genoegsame inligting rakende die kliniese inligting in my praktyk.
The system provides me with sufficient information regarding the clinical records in my practice. 1 2 3 4 5

9. Die stelsel maak voorsiening vir die totale mediese rekord.
The system provides for the total medical record. 1 2 3 4 5

10. Dit is maklik om dit wat ek in die stelsel wil doen, in die hande te kry.
It is easy to find what I need to do in the system. 1 2 3 4 5

11. Die hoeveelheid tikwerk wat ek moet doen, is aanvaarbaar.
The amount of typing I need to do is acceptable. 1 2 3 4 5

12. Die interaksie met die stelsel is duidelik en verstaanbaar.
The interaction with the system is clear and understandable. 1 2 3 4 5

13. My produktiwiteit sal verbeter deur die stelsel te gebruik.
My productivity will increase by using the system. 1 2 3 4 5

14. Die stelsel is oor die algemeen maklik om te gebruik.
Overall the system is easy to use. 1 2 3 4 5

15. Die stelsel is oor die algemeen maklik om aan te leer.
Overall the system is easy to learn. 1 2 3 4 5

16. Oor die algemeen is die reaksietyd van die stelsel goed.
Overall the response time of the system is good. 1 2 3 4 5

17. Ek sal meer tyd hê vir pasiëntesorg tydens konsultasies.
I shall have more time for patient care during consultations. 1 2 3 4 5

18. Ek sal bereid wees om die stelsel persoonlik te gebruik.
I shall be willing to personally use this system. 1 2 3 4 5

19. Ek sal bereid wees om die stelsel persoonlik in die teenwoordigheid van die pasiënt te gebruik.
I shall be willing to personally use this system in the presence of the patient. 1 2 3 4 5

20. Die gebruik van die stelsel sal die vertrouensverhouding met die pasiënt laat voortbestaan.
The use of the system will maintain the relationship of trust with the patient. 1 2 3 4 5

21. Hierdie stelsel is presies wat ek van 'n elektroniese pasiënt rekordstelsel verwag het.
This system is precisely what I envisioned an electronic patient record system to be. 1 2 3 4 5

22. Ek sal bereid wees om in die toekoms deel te neem aan die daarstelling van 'n algemeen aanvaarbare elektroniese pasiënt rekordstelsel.
I shall be willing to participate in the establishing of a generally acceptable electronic patient record system in future. 1 2 3 4 5

23. Algemene opmerkings, kritiek of aanbevelings rakende die stelsel.
General comments, critique or recommendations regarding the system:

Notas/vrae vir bespreking na aanleiding van die demonstasie van die stelsel.
Notes/questions for discussion as a result of the demonstration of the system.

ELEKTRONIESE PASIëNT REKORD PROTOTIPE 2 / *ELECTRONIC PATIENT RECORD PROTOTYPE 2*

EVALUASIE / *EVALUATION*
17 Maart / March 1999

Naam/*Name* : _____

Adres/*Address* : _____

_____

_____

_____

Tel.Nr. : _____

E-pos/*E-mail* : _____

(Die voltooiing van bogenoemde inlingting is opsioneel / *The completion of the information above is optional.*)

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   The task to register a new family is easy. 1 2 3 4 5

2. Daar bestaan gerieflike metodes om 'n familie op te spoor.
   There are convenient means to search for a family. 1 2 3 4 5

3. Die taak om 'n nuwe pasiënt te registreer, is maklik.
   The task to register a new patient is easy. 1 2 3 4 5

4. Daar bestaan gerieflike metodes om 'n pasiënt op te spoor.
   There are convenient means to search for a patient. 1 2 3 4 5

5. Die stelsel maak voorsiening vir al die algemene praktisyn se basiese kliniese dienste.
The system provides for all the basic general practitioner clinical services. 1 2 3 4 5

6. Die stelsel stem baie ooreen met die ou manier van dinge doen (die handstelsel).
The system corresponds closely to the old way of doing things (the manual system). 1 2 3 4 5

7. Die stelsel is 'n verbetering op die handstelsel.
The system is an improvement on the manual system. 1 2 3 4 5

8. Die stelsel verseker, waar moontlik, dat die data wat ingevoer word, geldig is.
The system ensures that the entered data is valid to the extent possible. 1 2 3 4 5

9. Die stelsel voorsien my van genoegsame inligting rakende die kliniese inligting in my praktyk.
The system provides me with sufficient information regarding the clinical records in my practice. 1 2 3 4 5

10. Die stelsel maak voorsiening vir die totale mediese rekord.
The system provides for the total medical record. 1 2 3 4 5

11. Die stelsel bied te veel detail.
The system provides for too much detail. 1 2 3 4 5

12. Die stelsel bied te min detail.
The system provides for too little detail. 1 2 3 4 5

13. Dit is maklik om dit wat ek in die stelsel wil doen, in die hande te kry.
It is easy to find what I need to do in the system. 1 2 3 4 5

14. Dit is maklik om tussen die skerms rond te beweeg.
It is easy to move among the different screens. 1 2 3 4 5

15. Die stelsel bied my genoeg vryheid en dwing nie vasgestelde volgordes op my af nie.
The system provides me with adequate freedom and does not force me to follow predefined sequences. 1 2 3 4 5

16. Die hoeveelheid tikwerk wat ek moet doen, is aanvaarbaar.
The amount of typing I need to do is acceptable. 1 2 3 4 5

17. Die interaksie met die stelsel is duidelik en verstaanbaar.
The interaction with the system is clear and understandable. 1 2 3 4 5

18. Die stelsel (gebruikerkoppelvlak) is visueel goed versorg, goed uitgelê en is aanvaarbaar.
The system (user interface) is visually well organised and is acceptable. 1 2 3 4 5

19. My produktiwiteit sal verbeter deur die stelsel te gebruik.
My productivity will increase by using the system. 1 2 3 4 5

20. Die stelsel is oor die algemeen maklik om te gebruik.
Overall the system is easy to use. 1 2 3 4 5

21. Die stelsel is oor die algemeen maklik om aan te leer.
Overall the system is easy to learn. 1 2 3 4 5

22. Oor die algemeen is die reaksietyd van die stelsel goed.
Overall the response time of the system is good. 1 2 3 4 5

23. Ek sal meer tyd hê vir pasiëntesorg tydens konsultasies.
I shall have more time for patient care during consultations. 1 2 3 4 5

24. Ek sal bereid wees om die stelsel <u>persoonlik</u> te gebruik.
I shall be willing to <u>personally</u> use this system. 1 2 3 4 5

25. Ek sal bereid wees om die stelsel persoonlik in die <u>teenwoordigheid van die pasiënt</u> te gebruik.
I shall be willing to personally use this system in the <u>presence of the patient</u>. 1 2 3 4 5

26. Die gebruik van die stelsel sal die vertrouensverhouding met die pasiënt laat voortbestaan.
The use of the system will maintain the relationship of trust with the patient. 1 2 3 4 5

27. Hierdie stelsel is presies wat ek van 'n elektroniese pasiënt rekordstelsel verwag het.
This system is precisely what I envisioned an electronic patient record system to be. 1 2 3 4 5

28. Ek sal bereid wees om in die toekoms deel te neem aan die daarstelling van 'n algemeen aanvaarbare elektroniese pasiënt rekordstelsel.
I shall be willing to participate in the establishing of a generally acceptable electronic patient record system in future. 1 2 3 4 5

29. Algemene opmerkings, kritiek of aanbevelings rakende die stelsel.
General comments, critique or recommendations regarding the system:

HUB STELSEL EVALUASIE / HUB SYSTEM *EVALUATION*

17 Maart / March 1999

Beoordeel hierdie sagteware prototipe in terme van die volgende deur u keuse met 'n X op die toepaslike nommer aan te dui:
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3. Die stelsel maak voorsiening vir al die algemene praktisyn se basiese kliniese dienste.
   The system provides for all the basic general practitioner clinical services. 1 2 3 4 5

4. Die stelsel stem baie ooreen met die ou manier van dinge doen (die handstelsel).
   The system corresponds closely to the old way of doing things (the manual system). 1 2 3 4 5

5. Die stelsel is 'n verbetering op die handstelsel.
   The system is an improvement on the manual system. 1 2 3 4 5

6. Die stelsel verseker, waar moontlik, dat die data wat ingevoer word, geldig is.
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   The system provides me with sufficient information regarding the clinical records in my practice. 1 2 3 4 5

8. Die stelsel maak voorsiening vir die totale mediese rekord.
The system provides for the total medical record. 1 2 3 4 5

9. Die stelsel bied te veel detail.
The system provides for too much detail. 1 2 3 4 5

10. Die stelsel bied te min detail.
The system provides for too little detail. 1 2 3 4 5

11. Die beginsel van "Foresighted Practice Guidelines" as basis vir 'n rekenaarstelsel is vir my aanvaarbaar.
Basing a computer system on the Foresighted Practice Guidelines principle is acceptable. 1 2 3 4 5

12. Dit is maklik om dit wat ek in die stelsel wil doen, in die hande te kry.
It is easy to find what I need to do in the system. 1 2 3 4 5

13. Dit is maklik om tussen die skerms rond te beweeg.
It is easy to move among the different screens. 1 2 3 4 5

14. Die stelsel bied my genoeg vryheid en dwing nie vasgestelde volgordes op my af nie.
The system provides me with adequate freedom and does not force me to follow predefined sequences. 1 2 3 4 5

15. Die hoeveelheid tikwerk wat ek moet doen, is aanvaarbaar.
The amount of typing I need to do is acceptable. 1 2 3 4 5

16. Die interaksie met die stelsel is duidelik en verstaanbaar.
The interaction with the system is clear and understandable. 1 2 3 4 5

17. Die stelsel (gebruikerkoppelvlak) is visueel goed versorg, goed uitgelê en is aanvaarbaar.
The system (user interface) is visually well organised and is acceptable. 1 2 3 4 5

18. My produktiwiteit sal verbeter deur die stelsel te gebruik.
My productivity will increase by using the system. 1 2 3 4 5

19. Die stelsel is oor die algemeen maklik om te gebruik.
Overall the system is easy to use. 1 2 3 4 5

20. Die stelsel is oor die algemeen maklik om aan te leer.
Overall the system is easy to learn. 1 2 3 4 5

21. Oor die algemeen is die reaksietyd van die stelsel goed.
Overall the response time of the system is good. 1 2 3 4 5

22. Ek sal meer tyd hê vir pasiëntesorg tydens konsultasies.
I shall have more time for patient care during consultations. 1 2 3 4 5

23. Ek sal bereid wees om die stelsel persoonlik te gebruik.
I shall be willing to personally use this system. 1 2 3 4 5

24. Ek sal bereid wees om die stelsel persoonlik in die teenwoordigheid van die pasiënt te gebruik.
I shall be willing to personally use this system in the presence of the patient. 1 2 3 4 5

25. Die gebruik van die stelsel sal die vertrouensverhouding met die pasiënt laat voortbestaan.
The use of the system will maintain the relationship of trust with the patient. 1 2 3 4 5

26. Hierdie stelsel is presies wat ek van 'n elektroniese pasiënt rekordstelsel verwag het.
This system is precisely what I envisioned an electronic patient record system to be. 1 2 3 4 5

27. Algemene opmerkings, kritiek of aanbevelings rakende die stelsel.
General comments, critique or recommendations regarding the system:

_____

_____

_____

_____

_____

_____

_____

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_____

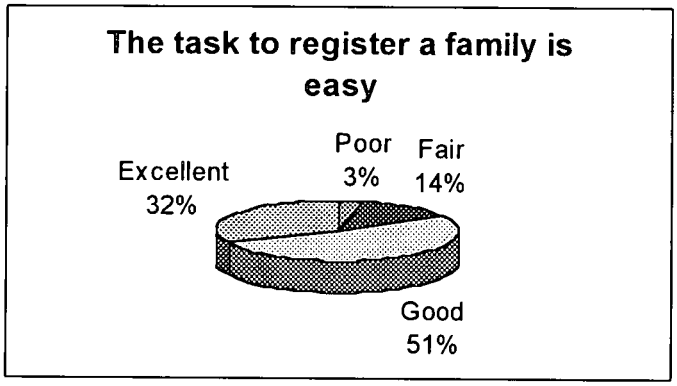
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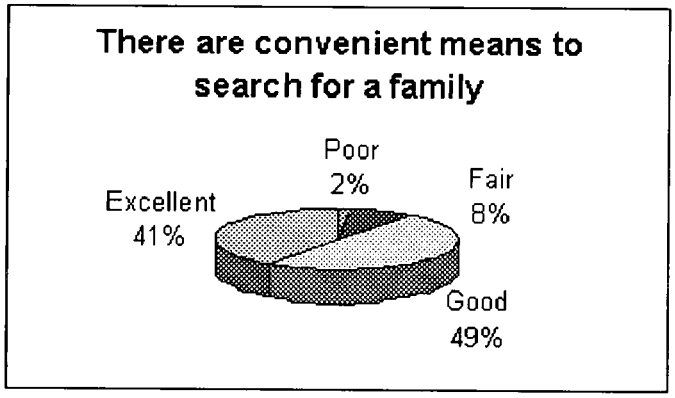
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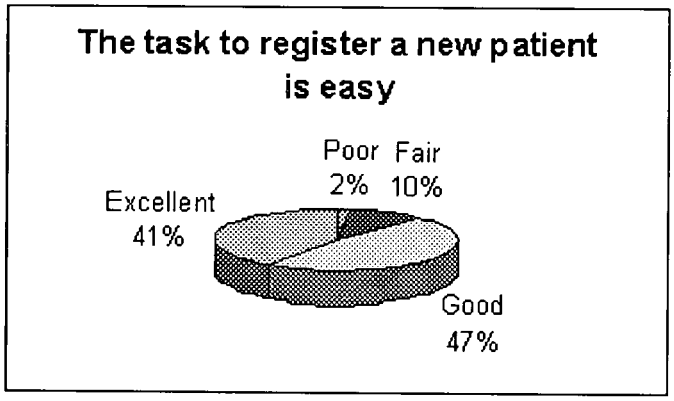
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Appendix F

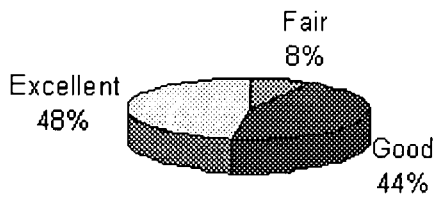
Graphical presentation of the results of the evaluation of the first EPR prototype



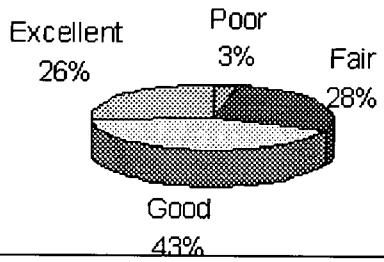




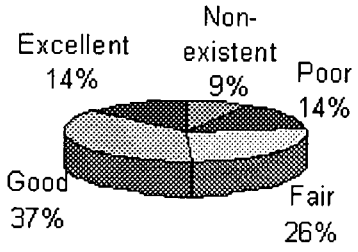
There are convenient means to search for a patient

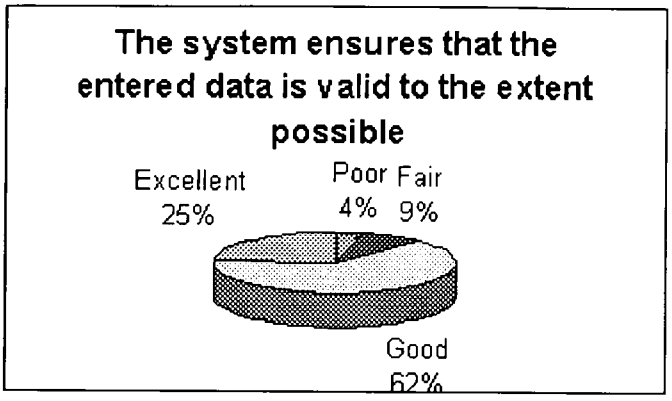


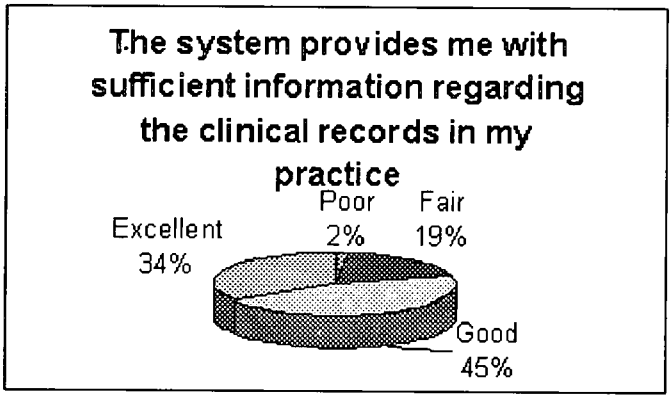
The system provides for all the basic general practitioner clinical services

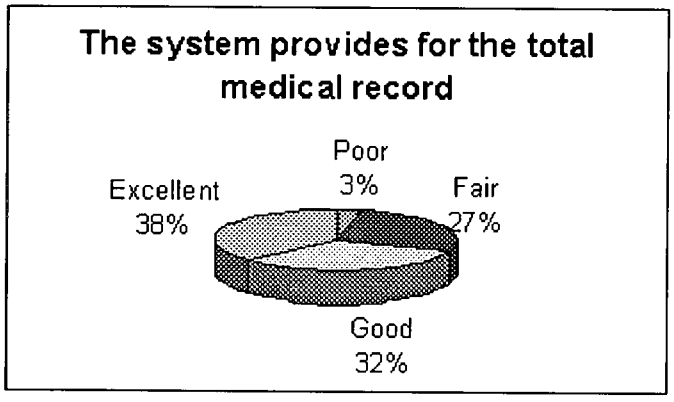


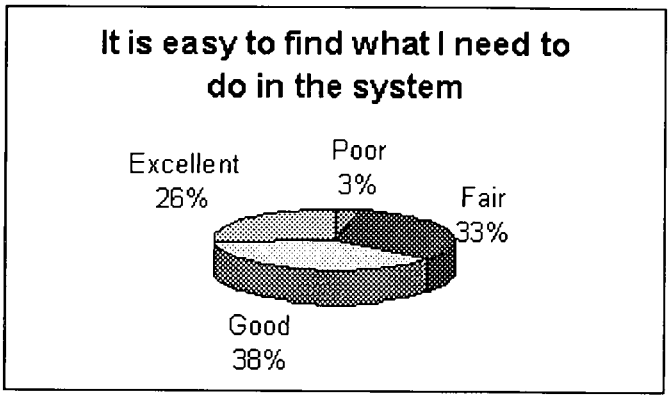
The system corresponds closely to the old way of doing things

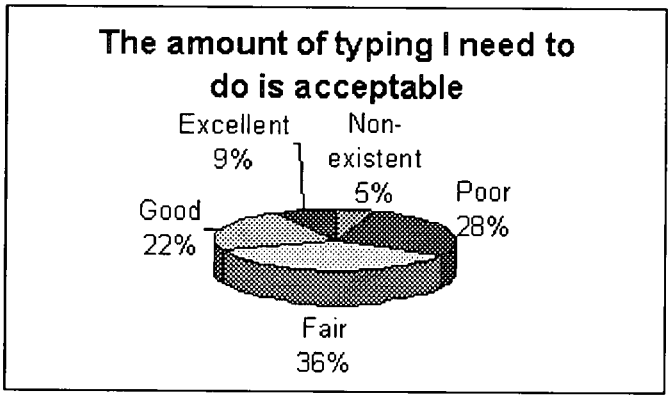


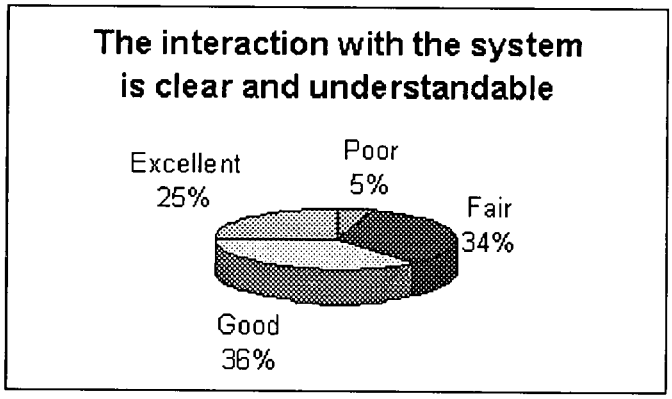

The system ensures that the entered data is valid to the extent possible
Excellent 25%
Poor 4%
Fair 9%
Good 62%

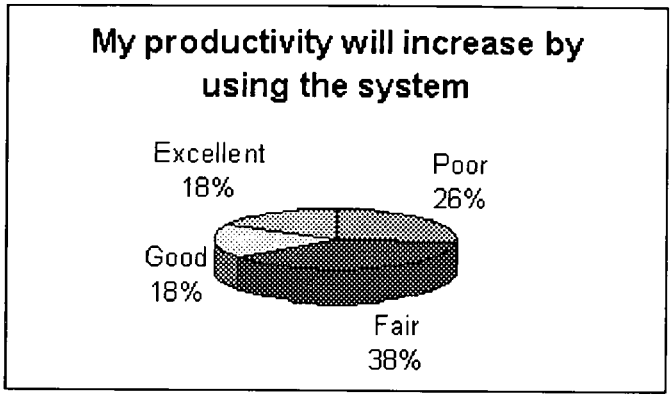

The system provides me with sufficient information regarding the clinical records in my practice
Excellent 34%
Poor 2%
Fair 19%
Good 45%

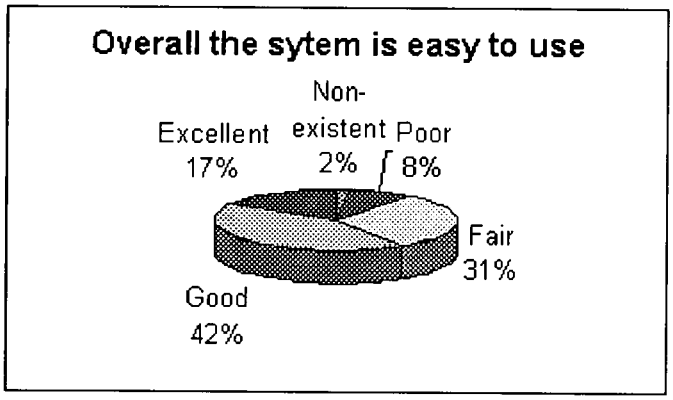

The system provides for the total medical record
Excellent 38%
Poor 3%
Fair 27%
Good 32%

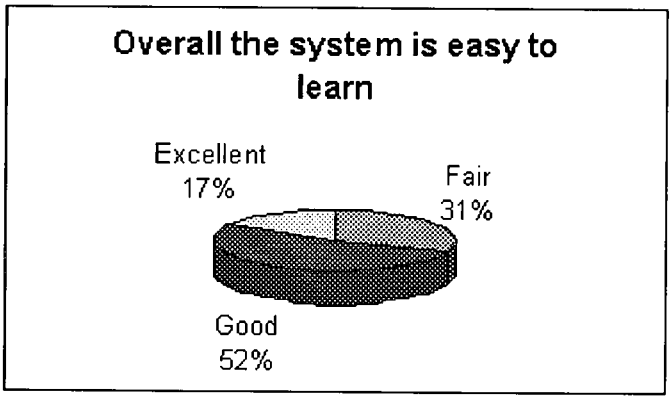

It is easy to find what I need to do in the system
Excellent 26%
Poor 3%
Fair 33%
Good 38%


The amount of typing I need to do is acceptable
Excellent 9%
Non-existent 5%
Poor 28%
Good 22%
Fair 36%

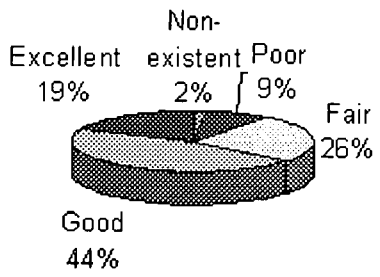

The interaction with the system is clear and understandable
Excellent 25%
Poor 5%
Fair 34%
Good 36%


My productivity will increase by using the system
Excellent 18%
Poor 26%
Good 18%
Fair 38%

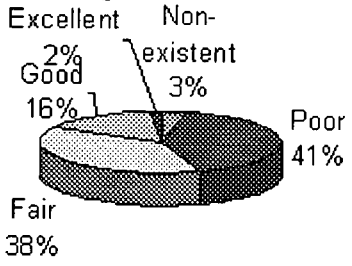

Overall the sytem is easy to use
Non-existent 2%
Excellent 17%
Poor 8%
Fair 31%
Good 42%


Overall the system is easy to learn
Excellent 17%
Fair 31%
Good 52%

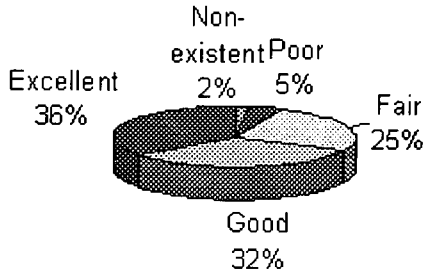
Overall the response time of the system is good



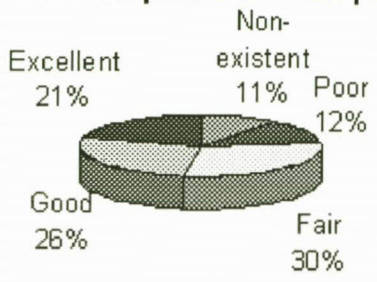
I shall have more time for patient care during consultations



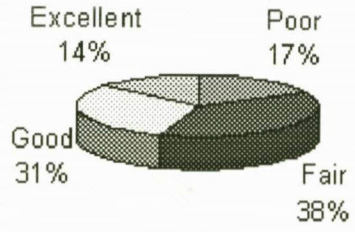
I shall be willing to personally use this system



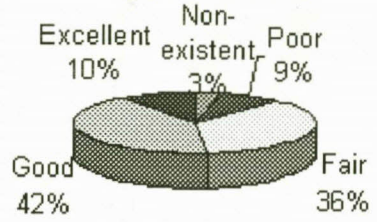
I shall be willing to personally use this system in the presence of the patient

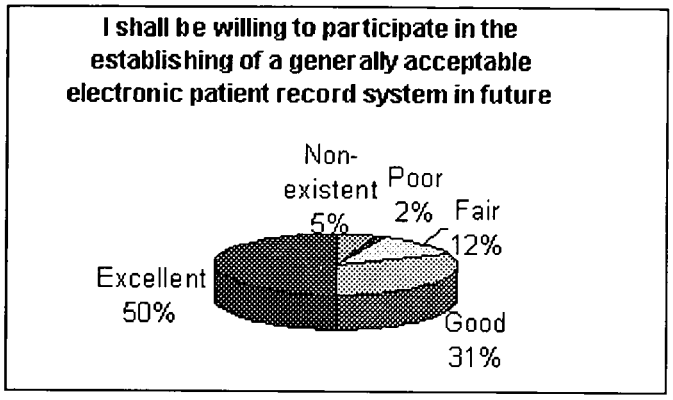


The use of the system will maintain the relationship of trust with the patient



The system is precisely what I envisioned an electronic patient record system to be




I shall be willing to participate in the establishing of a generally acceptable electronic patient record system in future
Non-existent 5%
Poor 2%
Fair 12%
Excellent 50%
Good 31%

Appendix G

Task sheet used during observation evaluation

EPR SYSTEM (PROTOTYPE 1 & 2)
EVALUATION PROCESS – 1999

1. TASK FOR TASK-ANALYSIS

Concise problem statement

Create a clinical note for a patient consultation using a general practice related Electronic Patient Record (EPR) system.

Detailed problem statement

Logon to the general practice related Electronic Patient Record (EPR) system using the user code and password, retrieve a family and patient, create a clinical note for the patient, study this visually, and thereafter logoff from the system.

Detailed task particulars

Family:	CF Jordaan Account Number = F1
Patient:	CF Jordaan
Main Complaint:	Fever, malaise, general body pains, cough, pain in R ear
Nature of consultation:	Consultation
First/Follow-up:	First
Length:	1,7
Weight:	100
General Appearance:	Glands ✔
Side room Examination:	Chest X-ray
Problems:	Flu R otitis media
Differential Diagnosis:	Flu Glandular fever
Cx:	C/B 5 days

2. TASK 2

2.1 Please logon to the EPR system if you have not done so already.
2.2 Retrieve the family CF Jordaan (Account Number F1).
2.3 Select patient CF Jordaan.
2.4 Go to the History screen.
2.5 Please do the following tasks:

2.5.1 Previous Illness

Add:

Previous illness	*Date*	*Remarks*
1. Bronchitis	1994/06	
2. Measles	1968	

Delete:

2. Measles	1968	

2.5.2 Previous Injuries

Add:

Previous injury	*Date*	*Remarks*
1. # clavicula L	1983/07/12	Rugby
2. Laceration L hand	1990/08/10	
3. FB in eye	1992/09	Welding

Change:

2. Add remark: IOD. Forms completed.

2.5.3 Previous Examinations

Add:

Previous examination	*Date*	*Remarks*
1. X/R clavicula L	1983/07/12	#

Delete:

1. X/R clavicula L	1983/07/12	#

2.5.4 Previous Medication

Add:

Previous medication	*Date*	*Remarks*
1. Augmentin 625	1999/08/10	
2. Voltaren	1999/08/10	

Change:

1. Add remark: Stop Voltaren

2.5.5 Previous Allergies

Simply look at the information and close the screen again.

3. TASK 3

3.1 Please logon to the EPR system if you have not done so already.
3.2 Retrieve the family CF Jordaan (Account Number F1).
3.3 Select patient CF Jordaan.
3.4 Go to the History screen.
3.5 Detail task particulars:

Main Complaint: Feeling better.
Cough now productive.

Nature of consultation: Consultation
First/Follow-up: Follow-up
Length: 1,7
Weight: 98

Problems: Bronchitis

Cx: C/B 4 days

3.6 Go back and change the **Main Complaint** by adding the following:

Nauseous, loss of appetite – 3 days

3.7 Save the consultation.
3.8 Log off.

oooOooo

Appendix H

Evaluation sheet used by evaluator during observational evaluation

EPR PROTOTYPE 1 AND 2 EVALUATION SHEET

Subject: _____

1. TASK 1

1.1	*Time duration for task:*
1.2	*Number of times that the user asked for assistance:*
1.3	*Number of times that the user expressed frustration:*
1.4	*Number of times that the user is prohibited from following a step/path:*
1.5	*Number of static default values on the screen:*
1.6	*Number of dynamic default values on the screen:*
1.7	*Number of times where the user would want options/different values.*
1.8	*List of objects / screen elements used in order of use:*

2. TASK 2

1.1	*Time spent on errors:*
1.2	*Number of errors:*
1.3	*Number of times where ENTER was pressed instead of TAB:*
1.4	*Number of times where keyboard-use was attempted in vain:*
1.5	*Number of times that a message appears in the Status line:*
1.6	*Number of times where the system asked for confirmation:*
1.7	*Number of times where output on tables were used for input:*
1.8	*Others:*

3. TASK 3

1.1	*Time duration to make the correction:*
1.2	*Number of steps necessary to make correction:*
1.3	*Steps necessary to make correction:*
1.4	General comments on Prototype 1:

Appendix I

Installation procedures

EPR SYSTEM (Prototype 1) : INSTALLATION PROCEDURES

Minimum computer requirements
As a general rule, 16 MEG RAM and 1 GIG hard drive. Windows 95 or later.

Steps

1. Switch on the computer and wait till the desktop appears on the screen.

2. Before you install the program, it is important to change certain Control Panel options. You are deliberately asked to change this manually, as you may want to change it back later as this prototype will only be on your computer temporarily.

    - Click on the *Start*-button of Windows95
    - Click on *Settings*
    - Select *Control Panel*
    - Double-click on *Regional Settings*
    - Click on the *Number* option
        - Change *Decimal symbol:* to , (comma)
        - Change *Digit grouping symbol* to a space
        - Click on *Apply*
    - Click on the *Date* option
        - Change *Short date style* to dd/mm/yyyy
        - Change *Date separator* to /
        - Click on OK and close the *Control Panel.*

3. Click on the *Start* button
4. Place the diskette marked as #1 in the stiffy drive.
5. Click on Run and type *a:* and press the ENTER key (or Click on OK)
6. Double-click on the Setup.exe. icon (the one with the small computer screen and box).
7. Follow the installation instructions. In most cases it is only necessary to ENTER at all choices, unless you want to change the drive where the program is to be installed. Follow the instructions until all the diskettes (#1 – #5) have been used.
8. As soon as the installation is completed, close all open windows. Click on the *Start*-button. Choose *Programs* and then *EPR1* and move the mouse to the right and again select *EPR Prot. 1.*
9. The EPR-program is now being loaded. As soon as the Logon screen appears, you may start using the program.

EPR SYSTEM (Prototype 2) : INSTALLATION PROCEDURES

Minimum computer requirements
As a general rule, 16 MEG RAM and 1 GIG hard drive. Windows 95 or later.

Steps

1. Switch on the computer and wait till the desktop appears on the screen.

2. Before you install the program, it is important to change certain Control Panel options. You are deliberately asked to change this manually, as you may want to change it back later as this prototype will only be on your computer temporarily.

    - Click on the *Start*-button of Windows95
    - Click on *Settings*
    - Select *Control Panel*
    - Double-click on *Regional Settings*
    - Click on the *Number* option
        - Change *Decimal symbol:* to , (comma)
        - Change *Digit grouping symbol* to a space
        - Click on *Apply*
    - Click on the *Date* option
        - Change *Short date style* to yyyy/mm/dd
        - Change *Date separator* to /
        - Click on OK and close the *Control Panel.*

3. Click on the *Start* button
4. Place the diskette marked as #1 in the stiffy drive.
5. Click on Run and type *a:* and ENTER (or Click on OK)
6. Double-click on the Setup.exe. icon (the one with the small computer screen and box).
7. Follow the installation instructions. In most cases it is only necessary to ENTER at all choices, unless you want to change the drive where the program is to be installed. Follow the instructions until all the diskettes (#1 – #5) have been used.
8. As soon as the installation is completed, close all open windows. Click on the *Start*-button. Choose *Programs* and then *EPR* and move the mouse to the right and again select *EPR.*
9. The EPR-program is now being loaded. As soon as the Logon screen appears, you may start using the program.

Appendix J

Example consultations

EPR (Prototype 1) EXAMPLE CONSULTATION 1999

1. LOGON SCREEN

1.1 Keep the *user id* and the *password* exactly as it appears on the screen.

1.2 Single-click on the OK button.

1.3 The *Families* screen appears.

2. FAMILIES SCREEN

2.1 On the dark-grey section, type F1 in the *Account Number* field and press the TAB key. This action activates the search for the family with account number F1. (If the dark-grey search area does not appear on the screen, click the *Search*-button in the right-hand corner of the screen).

2.2 The information of family Jordaan with *Account Number* F1 are displayed on the *Families* screen. A list of all the *dependants* of this family simultaneously appears on the left lower side of the screen. These dependants each represents a specific patient.

2.3 To illustrate the alternative search method, single-click on the *Search* button.

2.4 On the dark-grey search area, press the TAB key once to place the cursor in the *Surname* field. Type Jo in the *Surname* field and press the TAB key. ("Jo" is the first part of *Jordaan*).

2.5 On the left-hand side of the *Family* screen a list of all the families complying with the search criteria will appear under the heading *Choose a Family*.

2.6 Dubble-click on the family *Jordaan* with initials *CF*.

2.7 The information of the family CF Jordaan with *Account Number* F1 are displayed on the *families* screen. Simultaneously a list of all the *dependants* of this family appears on the lower left side of the screen. These dependants each represents a specific patient.

2.8 Dubble-click on *Christiaan Frederik* in the *Dependants* list to see the patient record.

3. **PATIENTS SCREEN**

3.1 The *Patients* screen of CF Jordaan are displayed. Carefully look at all the fields being displayed. Allergies of a patient appear in red on the upper right side of the screen.

3.2 On the left side of the screen a list of all the patient's previous consultation dates (*Previous Appointments)* appear. To look at one of these consultations, double-click on the consultation date *1999/08/10 11:05:59 AM* on the list. A summary of this consultation is displayed. The first screen displays the previous consultation screen. By clicking on the *General appearance, Systemic & Side Room Examination* button, these fields are displayed to the user. Press the *Cancel* button to close the screen. Options to view the Assessment and Plan information exist with the buttons at the top of the screen.

3.3 Single-click on the Close button. After clicking the Close button, you are brought back to the patient record.

3.4 You are now ready to create a new patient record. We are going to create the record for the wife of Mr CF Jordaan, Marie.

3.5 Single-click on the *New Patient* button on the *Patients* screen. The fields on the *Patients* screen are cleared and the system is ready to accept a new patient. Please type the following information in the appropriate fields / click on the appropriate choices in the selection lists. Please note that you have to use the *Tab*-key to move from field to field, and not the *Enter*-key. The information can be entered in the language of your choice. At this stage the system is, however, only available in English.

- Patient Id: P2
- Title: Mrs
- First Names: Marie Elizabeth
- Initials: *LW. By pressing the Tab after entering the First Names, the initials are automatically placed into the fields*
- Surname: Jordaan

- Gender: F
- Marital: Married
- Id No: 5102070015002

  As soon as the Tab-key is pressed after entering the Id no, the *Date of Birth* will automatically be displayed.
- Relationship: Wife
- Residential address: Type in the residential address in the provided fields.
- Occupation: Accountant
- Church: Dutch Reformed
- School: Menlo Park
- Remarks: If remarks are to be added, type the information in the block provided.

3.6 You are now ready to add a consultation for Marie Jordaan. It is being done according to the SOAP structure. For the evaluation purposes, you are provided with the following steps. Click on the *History (Subjective-part of SOAP)* button at the top of the screen for the history.

4. HISTORY(S) SCREEN

4.1 At *Main Complaint*, type:

Upper abdominal pain, heartburn – 6 months
Black stools 3 weeks
Weakness and shortness of breath – 10 days

4.2 Single-click on *Previous Illness*. Type the following:

Illness: Jaundice
Date: 1992/03
Note: Obstructive (gall stones)

Single-click on the OK button. Single-click on the CLOSE button.

4.3 Single-click on *Previous Operations*. Type the following:

Operation: Cholecystectomy
Date: 1992/06

Note: Gall bladder with gall stones removed

Single-click on the OK button. Single-click on the CLOSE button.

4.4 Single-click on *Previous Injuries*. Type the following:

Injury: Colles #

Date: 1995/03

Note: Reduction and POP

Single-click on the OK button. Single-click on the CLOSE button.

4.5 Single-click on *Previous Examinations.* Type the following:

Examination: Sonar gall bladder.

Date: 1992/05

Results: Gall stones +

Note:

Single-click on the OK button. Single-click on the CLOSE button.

4.6 Single-click on *Previous Medication.* Type the following:

Medication: NSAIM

Date: 1997/01

Note:

Single-click on the OK button. Single-click on the CLOSE button.

4.6 *Family History*: Type:

Father died (56) 1971 – miocardial infarct

Mother died (50) 1970 – M V A

Three healthy children (25, 21, 18)

4.7 *General Profile*: Type:

Smoke 40 sigs/day – 30 yrs

Drink 8 – 10 cups of coffee / day

Stress ++ at work

4.8 Single-click on *Systemic Inquiry* button. Do the following at the following systems:

Psyche: Anxious
CNS: Recurring headaches
Eyes: Rare double vision
ENT: Occasional ringing in the ears
CVS: Dyspnoea on exertion. Sleep on 3 pillows
Resp: Chronic cough – 3 months. White mucoid sputum. Worse at night.
GIT: See main complaint. Bad taste in mouth.
Uro: Nocturia
Genit: Slight vaginal discharge

Single-click on the OK button and Close the screen.

Single-click on the OK button at the bottom of the History screen.

4.9 You are now ready to complete the *Examination (Objective-part of SOAP).* Single-click on the *Examination (O)* button at the top of the screen. The *Examination/Consultation* screen are displayed.

5. **EXAMINATION(O) (Consultation) SCREEN**

5.1 Please note that you have to use the comma (,) to indicate decimals ant not the point (.).

Nature of consultation: Choose Consultation
First/Follow: Choose First

Type the following:

- Length: 1,7
- Weight: 104

- Body Mass Index: Automatically calculated.
- Abdominal circumference: 89
- Temperature: 37
- Pulse: 106
- Respiratory rate: 18
- Blood Pressure: 110/80

Click on the *General* button.

5.2 At *general appearance*, type the following:

- General: Overweight ++. Slightly pale appearance.
- Jaundice:
- Anaemia +
- Cyanosis
- Glands
- Clubbing of fingers
- Oedema

Click the OK button.

5.3 Single-click on the *Systemic* button. Enter the following systemic information:

Psyche: Anxious
CVS: Few extra systoles. Loud 2nd heart sound
Resp: Creps both lung bases
GIT: Tenderness epigantrium
Genit: Candida discharge
BI RE: Signs of anaemia

Single-click on the OK button and Close the screen.

5.4 Single-click on the *Sideroom* button. Select the following investigations and type the rest of the information:

Examination:	ECG
Remarks:	Few premature atrial contractions

Single-click the OK button and do the same with:

Examination:	Hemoglobin
Remarks:	8 gm/dl

Single-click on the OK button and Close the screen.

5.5 You are now going to complete the problem list by single-clicking on the *Assessment (A)* label on top of the screen.

6. **ASSESSMENT (A) SCREEN**

6.1 Enter the following problems:

Problem	Date
Dyspepsia	Choose today's consultation date
Tender epigastrium	"
Melaena	"
Stress at work	"
Smokes 40 sigs/day	"
Orthopnoea	"
Chronic cough	"
Vaginal Candidiasis	"
Obesity	"

Click the CLOSE button at the bottom of the screen.

6.2 Type the following at *Differential/Final Diagnosis*:

Peptic ulcer

Gastritis
Chronic bronchitis

Click the OK button at the bottom of the *Examination/Consultation* screen.

6.3 Single-click on the *Plan (P)* button at the top of the screen to enter the Plan-part of SOAP.

7. **PLAN (P) SCREEN**

7.1 Dx

Select the following DX by double-clicking on the available Dx options:

Chest X/ray
Gastroscopy

7.2 Rx

Type the following in the block beneath Rx:

Tabs Antacid 30
Tds a.c.
Supps Candikill 10
PV bd

7.3 Cx

Type the following in the block beneath Cx.

Discuss diet for obesity.
Recommend: cut down on smoking, coffee
Discontinue NSAID

Single-click on the OK button at the bottom of the Plan screen. If you wish to still make some changes, you may return to any screen by pressing the CLOSE button. If satisfied that the consultation is complete, press the *To Patient* button. After pressing

this button no changes may be made to this consultation. You are then being returned to the *Patients* screen where you may retrieve the next patient/family.

oooOooo

Thank you very much for your participation in our research project. It is truly appreciated.

EPR (Prototype 2) EXAMPLE CONSULTATION 1999

1. LOGON SCREEN

1.1 Single-click on Dr. G.J.Pistorius in the list.

1.2 Type the password, namely *aaaaa* (Note the lower case)

1.3 Single-click on the OK button.

1.4 The *Family* screen appears.

2. FAMILY SCREEN

2.1 Single-click on the Search button.

2.2 On the window appearing, type F1 in the *Account Id* field and single-click on the Search-button.

2.3 The information of family Jordaan with *Account Id* F1 are displayed. A list of all the *dependants* of this family simultaneously appears on the left lower side of the screen. These dependants each represents a specific patient.

2.4 To illustrate the alternative search method, single-click on the *Clear* button to clear the screen (the previous list of families will remain on the screen).

2.5 Single-click on the *Search* button.

2.6 On the window appearing, type Jo in the *Surname (part of)*-field and single-click on the Search-button. ("Jo" is the first part of *Jordaan*.)

2.7 On the left hand side of the *Family* screen a list of all the families complying with the search criteria will appear under the heading *Choose a Family*.

2.8 Dubble-click on the family *Jordaan* with initials *CF*.

2.9 The information of the family CF Jordaan with *Account Id* F1 are displayed on the *family* screen. Simultaneously a list of all the *dependants* of this family appears on the lower left side of the screen. These dependants each represents a specific patient.

2.10 Dubble-click on *Christiaan Frederik* in the *Dependants* list to see the patient record.

3. PATIENT SCREEN

3.1 The *Patient* screen of CF Jordaan are displayed. Carefully look at all the fields being displayed. Allergies of a patient appear in red on the lower left side of the screen.

3.2 On the left side of the screen a list of all the patient's previous consultation dates *(Previous Consultations)* appear. To look at one of these consultations, double-click on the consultation date *1999/03/09 9:54:40 AM* on the list. A summary of this consultation is displayed. It is important to again note at this stage that this is a prototype system and that this summary is not refined yet. The purpose of the evaluation it to evaluate the principle and the method of displaying previous consultations.

3.3 Single-click on the Close button. Do not click on any other buttons as none of these have been implemented yet. After clicking the Close button, you are brought back to the patient record.

3.4 You are now ready to create a new patient record. We are going to create the record for the wife of Mr CF Jordaan, Marie.

3.5 Single-click on the *New Patient* button on the *Patient* screen. The fields on the *Patient* screen are cleared and the system is ready to accept a new patient. Please type the following information in the appropriate fields / click on the appropriate choices in the selection lists. Please note that you have to use the *Tab*-key to move from field to field, and not the *Enter*-key. The information can be entered in the language of your choice. At this stage the system is, however, only available in English and the report headings will also only be available in English. If you enter the information in Afrikaans, it might be quite a mixture of languages. The English information is also available.

- Patient Id: P2
- Title: Mrs
- First Names: Marie Elizabeth
- Initials: *LW. By pressing the Tab after entering the First Names, the initials are automatically placed into the fields*
- Surname: Jordaan
- Gender: F

- Marital: Married
- Id No: 5102070015002

  As soon as the Tab-key is pressed after entering the Id no, the *Date of Birth*, as well as the age, will automatically be displayed.
- Residential address: The residential address are brought over from the family address. If it differs from the family, it can be modified by single-clicking on the icon in the residential address block.
- Occupation: Accountant
- Church: Dutch Reformed
- School: Menlo Park
- Remarks: If remarks are to be added, single-click on the *Display* radio-button and type the information in the block provided. When completed, single-click on the *Hide* radio-button.
- Medical Fund: The information is brought forward from the family field. It is unnecessary to modify this information.

3.6 You are now ready to add a consultation for Marie Jordaan. It is being done according to the SOAP structure, but you may change the order as you wish. For the evaluation purposes, you are provided with the following steps. Click on the *History (Subjective-part of SOAP)* label at the top of the screen for the history.

4. HISTORY(S) SCREEN

4.1 At *Main Complaint*, type:

Upper abdominal pain, heartburn – 6 months
Black stools 3 weeks
Weakness and shortness of breath – 10 days

4.2 Single-click on *Previous Illness.* Type the following:

Illness: Jaundice
Date: 1992/03
Note: Obstructive (gall stones)

Single-click on the OK button.

4.3 Single-click on *Previous Operations.* Type the following:

Operation: Cholecystectomy

Date: 1992/06

Note: Gall bladder with gall stones removed

Single-click on the OK button.

4.4 Single-click on *Previous Injuries.* Type the following:

Injury: Colles #

Date: 1995/03

Note: Reduction and POP

Single-click on the OK button.

4.5 Single-click on *Previous Investigations.* Type the following:

Investigation: Sonar gall bladder.

Date: 1992/05

Results: Gall stones +

Note:

Single-click on the OK button.

4.6 Single-click on *Previous Medication.* Type the following:

Medication: NSAIM

Date prescribed: 1997/01

Date discontinued:

Note:

Single-click on the OK button.

4.7 *Family History*: Type:

Father died (56) 1971 – miocardial infarct

Mother died (50) 1970 – M V A

Three healthy children (25, 21, 18)

4.8 *General Profile*: Type:

Smoke 40 sigs/day – 30 yrs
Drink 8 – 10 cups of coffee / day
Stress ++ at work

4.9 Single-click on *Systemic History* button. Do the following at the following systems:

Psyche: Anxious
CNS: Recurring headaches
Eyes: Rare double vision
ENT: Occasional ringing in the ears
CVS: Dyspnoea on exertion. Sleep on 3 pillows
Resp: Chronic cough – 3 months. White mucoid sputum. Worse at night.
GIT: See main complaint. Bad taste in mouth.
Uro: Nocturia
Genit: Slight vaginal discharge
Locom: NAD (Single-click on NAD block)
Ectod: NAD (Single-click on NAD block)
Endocr: NAD (Single-click on NAD block)
Bl RE: NAD (Single-click on NAD block)

Single-click on the OK button and Close the screen.

4.10 You are now ready to complete the *Examination (Objective-part of SOAP)*. Single-click on the *Examination (O)* label at the top of the screen. The *Examination*-screen are displayed.

5. EXAMINATION(O) SCREEN

5.1 Please note that you have to use the comma (,) to indicate decimals ant not the point (.). Type the following:

- Length: 1,7
- Weight: 104
- Body Mass Index: Automatically calculated.
- Abdominal circumference: 89
- Temperature: 37
- Pulse: 106
- Respiratory rate: 18
- Blood Pressure: 110/80

5.2 At *general appearance*, type the following:

- General: Overweight ++. Slightly pale appearance.
- Jaundice: -
- Anaemia +
- Cyanosis -
- Glands -
- Clubbing of fingers -
- Oedema -

5.3 Single-click on the *Systemic Examination* button. Enter the following systemic information:

Psyche: Anxious
CNS: NAD (Click on the small NAD block)
Eyes: NAD (Click on the small NAD block)
ENT: NAD (Click on the small NAD block)
CVS: Few extra systoles. Loud 2nd heart sound
Resp: Creps both lung bases
GIT: Tenderness epigantrium

Uro: NAD (Click on the small NAD block)

Genit: Candida discharge

Locom: NAD (Click on the small NAD block)

Ectod: NAD (Click on the small NAD block)

Endocr: NAD (Click on the small NAD block)

BI RE: Signs of anaemia

Single-click on the OK button and Close the screen.

5.4 Single-click on the *Sideroom Investigation* button. Select the following investigations and type the rest of the information:

Investigation: ECG

Results: Few premature atrial contractions

Note:

Single-click the OK button and do the same with:

Investigation: Hemoglobin

Results: 8 gm/dl

Note:

Single-click on the OK button and Close the screen.

5.5 You are now going to complete the problem list by single-clicking on the *Assessment (A)* label on top of the screen.

6. ASSESSMENT (A) SCREEN

6.1 Enter the following problems:

Problem	Date
Dyspepsia	Keep today's consultation date
Tender epigastrium	"
Melaena	"
Stress at work	"
Smokes 40 sigs/day	"
Orthopnoea	"
Chronic cough	"
Vaginal Candidiasis	"
Obesity	"

6.2 Type the following at *Differential Diagnosis*:

Peptic ulcer
Gastritis
Chronic bronchitis

6.3 Single-click on the *Plan (P)* label at the top of the screen to enter the Plan-part of SOAP.

7. PLAN (P) SCREEN

7.1 Dx

Select the following DX by double-clicking on the available Dx options:

Chest X/ray
Gastroscopy

7.2 Rx

Type the following in the block beneath Rx:

Tabs Antacid 30
Tds a.c.
Supps Candikill 10
PV bd

7.3 Cx

Type the following in the block beneath Cx. Select a follow-up date by single-clicking on the calendar icon next to the *follow-up* field. Choose a date on the calendar and click on the OK button.

Discuss diet fot obesity.
Recommend: cut down on smoking, coffee
Discontinue NSAID

For the last entry, return to the *Previous Medication* screen on the *History* page and add this information.

If satisfied that the consultation is complete, single-click on the *Confirm this Consultation* button. You may, however, return to any screen to make changes. After pressing the *Confirm this Consultation* button on the screen, changes may only be made on the *Modify* screen. Press the *Confirm this Consultation* button.

8. MODIFY SCREEN

8.1 Make the following modification:

- Date of consultation: Last consultation
- Modification: Cleaner at work has TB.

9. QUERY SCREEN

9.1 Do a query on family *Account Id* F1 and patient CF Jordaan.

10. MAINTAIN SCREEN

10.1 Lookup-tables are maintained on this page.

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Thank you very much for your participation in our research project. It is truly appreciated.

HUB-SYSTEM EXAMPLE CONSULTATION

17 March 1999

The following will give you a broad tour through the HUB system. This American system has been based on the use of Foresighted Practice Guidelines (FPGs). A Foresighted Practice Guideline is basically a set of decision tables, created by physicians, to guide the physician through a consultation. The emphasis lies on giving the individual physician the freedom to organise the guidelines according to his/her own personal preferences.

Please note that throughout the system, all selections are made by clicking the left mouse button (LMB) once, and all the selections are confirmed by clicking the right mouse button (RMB) once.

1. LOADING THE SYSTEM

1.1 From the Start-button of Windows 95, click on Run and type in the path c:\hub\hub and press OK.

1.2 The HUB screen will appear. Click the left mouse button (LMB) once anywhere on the screen to activate the program.

2. EXAMINER

2.1 From the "*Choose Examiner*" dialog box that appears, left-click on the first *Thomas A. Naegele, D.O.*

3. SELECT PATIENT

3.1 From the menu on the left side of the screen, click on the *Select Patient* option.

3.2 In the *Enter Last name, First Name* dialog box that appears, type in *De Wet* (case does not matter) and press the ENTER key.

3.3 The problem list for this patient will appear.

3.4 Click the right mouse button (RMB).

4. FORESIGHTED PRACTICE GUIDELINES

4.1 The list of foresighted practice guidelines (FPGs) will appear in a frame in the centre of the screen.

4.2 From the menu on the left side of the screen, left-click on the *Timestamp* option. The date and time of this new consultation will appear at the top of the screen. Wait for the FPGs to re-appear.

4.3 From the menu on the left side of the screen, left-click on the *Age* option. The age of the patient will appear at the top of the screen. Wait for the FPGs to re-appear.

4.4 Choose the FPG(s) to use for this consultation. As an example, left-click on the *ABD-PAIN* (Abdominal pain) FPG and press the RMB. (If the information block appearing on the screen does not start with *Front/Arrival*, click on the *Back up* option on the menu on the left of the screen and press the RMB. The detail of the FPG for *ABD-PAIN* will appear in the information block).

5. CONSULTATION

5.1 From now on you may proceed through the consultation at your own pace making your own choices.

5.2 Remember to always select with the LMB and to confirm with the RMB.

5.3 You may follow the guideline screen by screen, or you may jump forwards and backwards and skip certain sections by using the categories appearing in the block on the bottom left of the screen, e.g. Front, Symptom. The categories correlate to the SOAP model (in this case Symptoms, Objective, Assessment, Plan), but include two additional categories, namely Front (information traditionally found on the front of a patient chart) and Back (information in the back of the chart, e.g. handouts on diseases.

6. CONSULTATION DONE

6.1 When done, click on the *Patient Done* option on the left of the screen.

6.2 At any time during the consultation the note may be discarded by selecting the *Suspend* option, or by clicking on *More choices/Abandon note* option on the menu on the left of the screen.

7. EXIT HUB

7.1 To exit the HUB system, select the *More choices* option and then the *Exit Hub* option on the menu on the left of the screen.

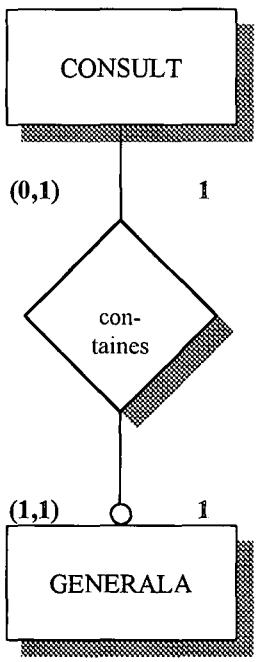
oooOooo

Thank you very much for your participation in our research project. It is truly appreciated.

Appendix K

Updated detail relationships among entities for the second prototype

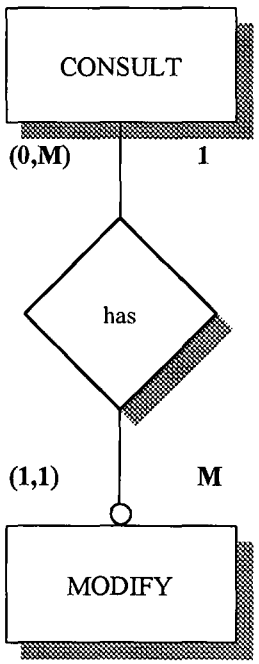
- **CONSULT and GENERALA**



A specific consultation may be associated with none or one GENERALIA record (general information on general appearance). Therefore GENERALA is dependent on CONSULT.

A specific GENERALA record may belong to only one consultation.

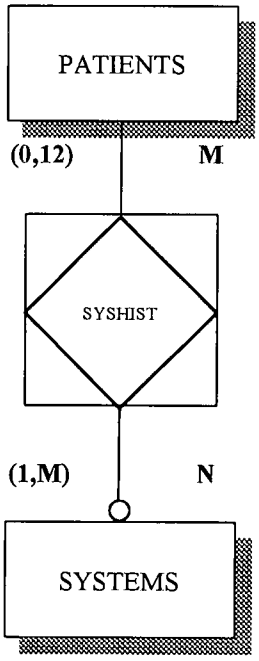
- **CONSULT and MODIFY**



For a consultation, a patient may have none or many MODIFY record. Therefore MODIFY is dependent on CONSULT.

A specific MODIFY record may belong to only one consultation.

- **PATIENTS and SYSTEMS (SysHist)**

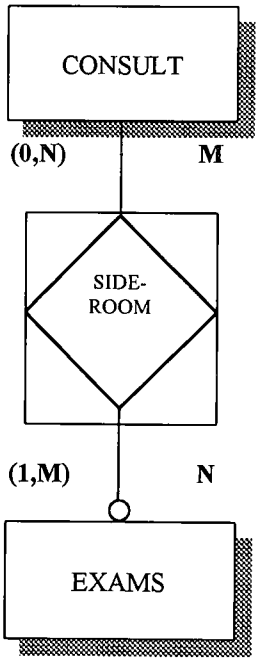


A patient may have information on none or 12 systems. Therefore SYSTEMS is optional for PATIENTS.

SYSHIST is a composite entity.

A system may be associated with one or more patients.

- **CONSULT and EXAMS (SideRoom)**

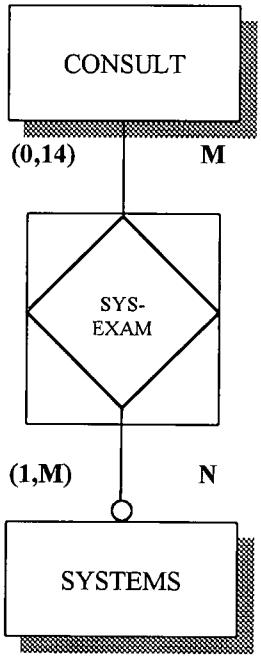


For a specific consultation, none or many side room investigations can be done on the patient. Therefore EXAMS is dependent on CONSULT.

SIDEROOM is a composite entity.

A specific side room investigation can be performed on many patients during many consultations.

- **CONSULT and SYSTEMS (SysExam)**

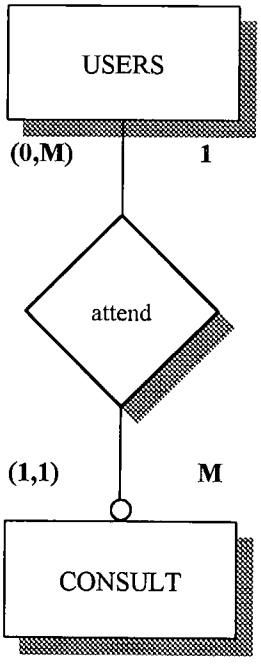


For a specific consultation a patient may be associated with none or up to 14 of the body systems. Therefore SYSTEMS is dependent on CONSULT.

SYSEXAM is a composite entity.

A system may be associated with many consultations.

- **USERS and CONSULT**



A USER may attend to none or many consultations (have none or many CONSULT records). Therefore CONSULT is dependent on USERS.

A specific CONSULT record may be attended by only one user in USERS.

Appendix L

Updated attributes for the entities of the second prototype

- **Entity: CONSULT**

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Con_ConsultId	Consultation identification number	PK
U_UserCode	Usercode of attending physician	
Nat_NatureId	Nature of consultation identification	FK to NATURE
Con_DateTime	Consultation date and time	
Con_TimeStamp	Behind the scenes timestamp of consultation	
Con_FirstFollow	First / Follow-up consultation	
Con_MainComplaint	Patient's main complaint	
Con_FamHist	Patient's family history	
Con_GenProfile	Patient's general profile	
Con_Length	Patient length in meters	
Con_Weight	Patient weight in kilograms	
Con_AbdomCirc	Patient abdominal circumference (cm)	
Con_Temp	Patient temperature	
Con_Pulse	Patient pulse rate	
Con_Breath	Patient respiratory rate	
Con_BloodPressure	Patient blood pressure	
Con_DiffDiagnosis	Differential diagnosis for consultation	

Entity CONSULT: Changes from First Prototype

- U_UserCode field added
- Con_TimeStamp field added
- Con_FamHist field added
- Con_GenProfile field added

- **Entity: EXAMS**

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
Ex_ExaminationId	Identification number of type of sideroom investigation	PK
Ex_Examination	Description of sideroom examination	

Entity EXAMS: Changes from First Prototype

- Entity name changed from SREXAMINATIONS to EXAMS
- Attribute Srex_ExaminationId changed to Ex_ExaminationId
- Attribute Srex_Examination changed to Ex_Examination

- **Entity: FAMILIES**

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
Fam_AccountId	Family account identification number	PK
T_TitleId	Title identification number	FK to TITLES
Fam_Initials	Family-head initials	
Fam_Surname	Family surname	
Fam_HomeAddress1	Family-head residential address	
Fam_HomeAddress2		
Fam_HomeAddress3		
Fam_HomeAddress4		
Fam_HomePostalCode	Postal code	
Fam_PostalAddress1	Family-head postal address	
Fam_PostalAddress2		
Fam_PostalAddress3		
Fam_PostalAddress4		
Fam_PostalCode	Postal code	
Fam_TelHome	Family-head home phone number	
Fam_TelWork	Family-head work phone number	
Fam_Cell	Family-head cellular number	
Fam_Fax	Family-head fax number	
Fam_Email	Family-head email address	
Mf_MedFundId	Family medical fund identification nr	FK to MEDFUNDS
Fam_MedFundNo	Medical fund membership number	
L_LanguageId	Language identification number	FK to LANGUAGE
Fam_CurrEmp	Family-head's current employer	
Fam_CurrEmpAddress	Address of current employer	
Fam_PrevEmp	Family-head's previous employer	
Fam_PrevEmpAddress	Address of previous employer	
Fam_PrevDoc	Family-head's previous doctor	
Fam_PrevDocAddress	Address of previous doctor	
Fam_Remarks	Remarks on the family	

Entity FAMILIES: Changes from First Prototype

- The residential address of the family-head is added to the entity as requested by the evaluators
- The e-mail address of the family-head is added as requested by the evaluators

- **Entity: GATSKE**

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
Ga_GatskeNr	Automatic numbering of GATSKE states	PK
Ga_GatskeId	Category of general appearance identification number	
Ga_Gatske	Description of category	

Entity GATSKE: Changes from First Prototype

- A new attribute Ga_GatskeNr replaces Ga_GatskeId as Primary Key

- **Entity: GENERALA**

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Con_ConsultId	Consultation identification number	PK
Gen_General	General remarks on a patient's general appearance	

Entity GENERALA: Changes from First Prototype

- Entity GENERALA was added to the database

- **Entity: MODIFY**

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
Mod_ModificationId	Automatic numbering of modifications	PK
P_PatientId	Patient identification number	
Con_ConsultId	Consultation identification number	
Mod_Modification	Detail of modification to consultation	
Mod_TimeStamp	Timestamp of when modification took place	

Entity MODIFY: Changes from First Prototype

- Entity MODIFY was added to the database

- **Entity: PALLERGY**

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Pal_AllergyNr	Automatic numbering of allergies per patient	PK
Pal_Allergy	Allergy description	
Pal_DateSince	Date since patient has had the allergy	
Pal_Note	Notes on the allergy	
Pal_TimeStamp	Timestamp of when record was entered into database	

Entity PALLERGY: Changes from First Prototype

- The attribute Pal_TimeStamp was added to keep track of when entries/changes were made in this entity

- **Entity: PATIENTS**

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Fam_AccountId	Family account identification number	FK to FAMILIES
T_TitleId	Patient title identification number	FK to TITLES
P_Initials	Patient initials	
P_Surname	Patient surname	
P_FirstName	Patient first names	
P_IdNo	Patient identification number	
P_DOB	Patient date of birth	
P_Gender	Patient gender (Male/Female)	
P_HomeAddress1	Patient residential address	
P_HomeAddress2		
P_HomeAddress3		
P_HomeAddress4		
P_HomePostalCode		
P_Occupation	Description of patient's occupation	
P_MaritalId	Patient marital state identification number	FK to MARITAL
P_Church	Patient church denomination	
P_School	School that patient attends/attended	
Rel_RelationshipId	Patient's relationship with family-head (identification number)	FK to RELATE
P_Remarks	Remarks on patient	
Mf_MedFundId	Identification no of medical fund to which patient belongs, if different from family	FK to MEDFUNDS
Fam_MedFundNo	Medical fund number allocated to patient, if different from family	

Entity PATIENTS: Changes from First Prototype

- Two additional residential address attributes, namely P_HomeAddress4 and P_HomePostalCode were added, as requested by the evaluators
- The medical fund and number (Mf_MedFundId and Fam_MedFundNo) attributes were added due to the fact that some Medical Funds allocate a number per patient instead of a number per family, as was the case in the past, as was requested by the evaluators

- **Entity: PCX**

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Con_ConsultId	Consultation identification number	
Pcx_Cx	Patient counselling/information	
Pcx_FollowUp	Date of follow-up consultation	

Entity PCX: Changes from First Prototype

- The attribute Pcx_FollowUp (a date field) was added to keep track of the follow-up consultation date

- **Entity: PREVEXAM**

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Pe_ExaminationNr	Automatic numbering of previous investigations per patient	PK
Pe_Examination	Description of previous investigation	
Pe_Date	Date that previous investigation took place	
Pe_Results	Results of previous investigation	
Pe_Note	Notes on previous investigation	
Pe_TimeStamp	Timestamp of when record was entered into database	

Entity PREVEXAM: Changes from First Prototype

- The attribute Pe_TimeStamp was added to keep track of the date and time of changes made to this entity

- **Entity: PREVILL**

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
Pi_IllnessNr	Automatic numbering of previous illnesses per patient	PK
P_PatientId	Patient identification number	PK
Pi_Illness	Description of previous illness	
Pi_Date	Date on which previous illness occurred	
Pi_Note	Notes on previous illness	
Pi_TimeStamp	Timestamp of when record was entered into database	

Entity PREVILL: Changes from First Prototype

- The attribute Pi_TimeStamp was added to keep track of the date and time of changes made to this entity

- **Entity: PREVINJU**

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Pin_InjuryNr	Automatic numbering of previous injuries per patient	PK
Pin_Injury	Description of previous injury	
Pin_Date	Date on which previous injury took place	
Pin_Note	Notes on previous injury	
Pin_TimeStamp	Timestamp of when record was entered into database	

Entity PREVINJU: Changes from First Prototype

- The attribute Pin_TimeStamp was added to keep track of the date and time of changes made to this entity

- **Entity: PREVMEDI**

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Pm_MedicineNr	Automatic numbering of previously taken medication per patient	PK
Pm_Medicine	Description of previous medication	
Pm_DatePres	Date when medication was prescribed	
Pm_DateDisc	Date when medicine was discontinued	
Pm_Note	Notes on previous medication	
Pm_TimeStamp	Timestamp of when record was entered into database	

Entity PREVMEDI: Changes from First Prototype

- The attribute Pm_TimeStamp was added to keep track of the date and time of changes made to this entity
- The attribute Pm_Date was replaced with the attribute Pm_DatePres, which contains the date that medication was prescribed to the patient
- The attribute Pm_DateDisc was added. It contains the date that the use of prescribed medicine was discontinued.

- **Entity: PREVOPS**

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Po_OperationNr	Automatic numbering of previous operations per patient	PK
Po_Operation	Description of previous operation	
Po_Date	Date on which previous operation was done	
Po_Note	Notes on previous operation	
Po_TimeStamp	Timestamp of when record was entered into database	

Entity PREVOPS: Changes from First Prototype

- The attribute Pe_TimeStamp was added to keep track of the date and time of changes made to this entity

- **Entity: SIDEROOM**

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Con_ConsultId	Consultation identification number	PK
Ex_ExaminationId	Identification number of type of sideroom examination	PK, FK to SREXAMINATIONS
Sr_Results	Results of sideroom investigations	
Sr_Notes	Notes on sideroom examination	

Entity SIDEROOM: Changes from First Prototype

- The attribute Sr_Results was added to enter the results of a sideroom investigation
- The attribute Sroomex_Remarks was replaced with the attribute Sr_Notes for entering notes on a sideroom investigation

- **Entity: SYSEXAM**

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Con_ConsultId	Consultation identification number	PK
Sys_SystemId	System identification number	PK,FK to SYSTEMS
SysExam_Remarks	Remarks per system per patient	

Entity SYSEXAM: Changes from First Prototype

- The name of the entity changed from SYSINQ to SYSEXAM
- The attribute name Sysinq_Remarks changed to Sysexam_Remarks

- **Entity: SYSHIST**

ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
P_PatientId	Patient identification number	PK
Con_ConsultId	Consultation identification number	PK
Sys_SystemId	System identification number	PK, FK to SYSTEMS
SysHist_Remarks	Remarks per system per patient	

Entity SYSHIST: Changes from First Prototype

- Entity name changed from HISTSYS to SYSHIST
- Con_ConsultId attribute was added in order to link the systemic history to a consultation, as requested by the evaluators
- The Primary Key was extended to consist of P_PatientId, Con_ConsultId and SYS_SystemId
- The name of the attribute Hsys_Remarks changed to SysHist_Remarks

- **Entity: USERS**

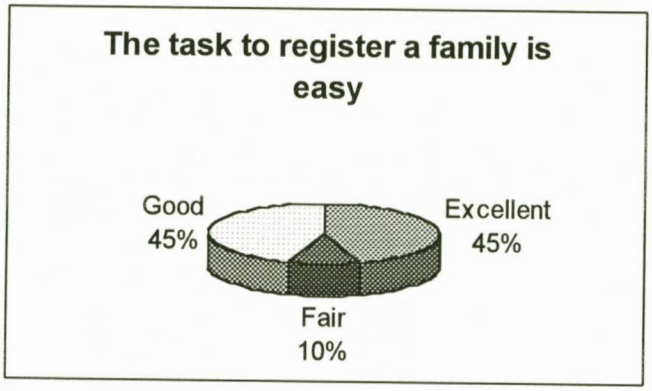
ATTRIBUTE	CONTENT	PRIMARY(PK)/ FOREIGN(FK) KEYS
U_UserCode	Usercode of physician / user	PK
U_Password	Password of physician / user	
U_Physician	Name of physician / user	

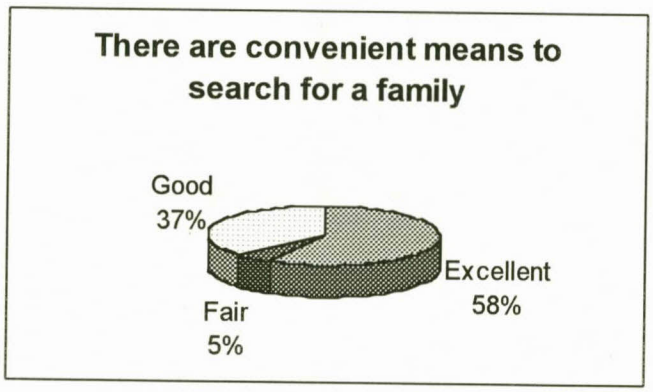
Entity USERS: Changes from First Prototype

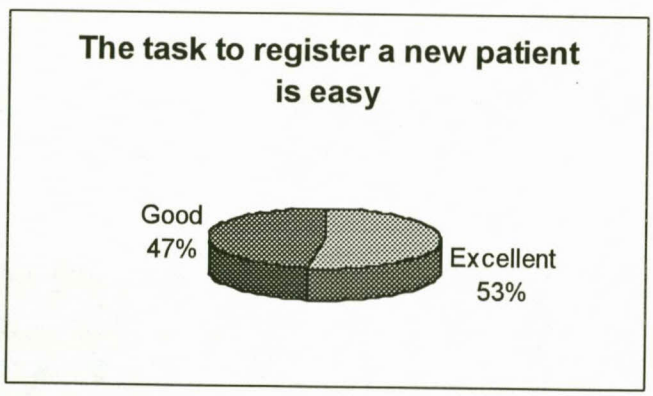
- The entity USERS was added to the database.

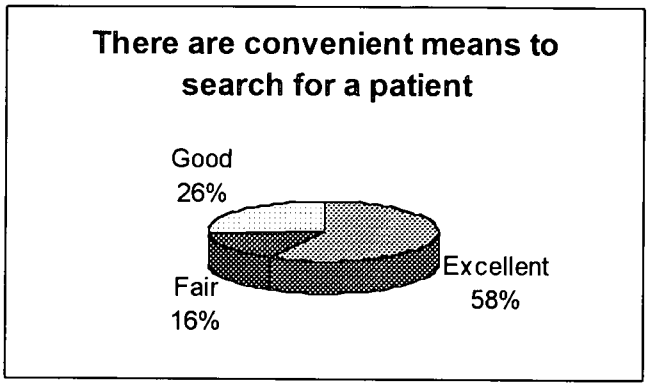
Appendix M

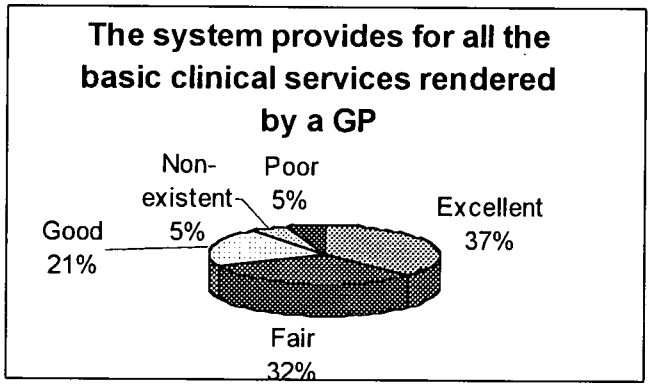
Graphical presentation of the evaluation results of the second EPR prototype

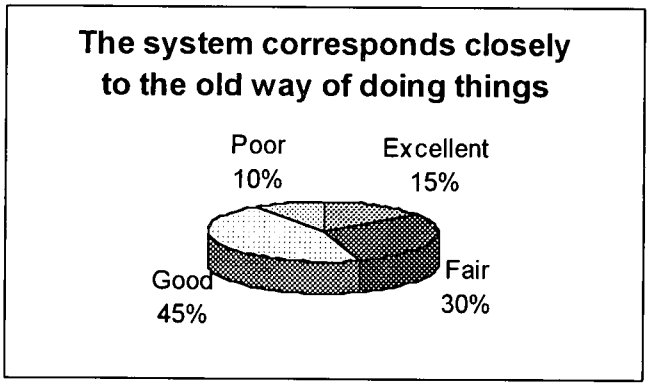


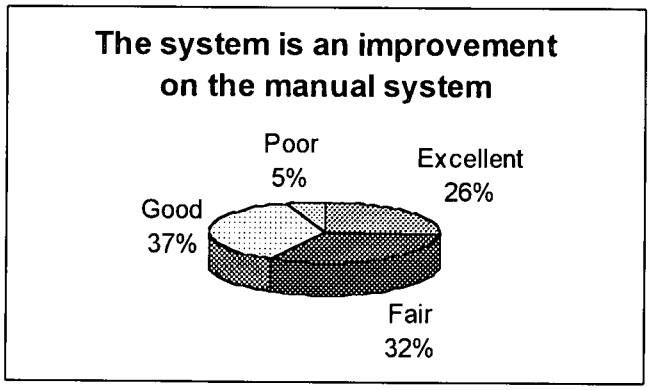




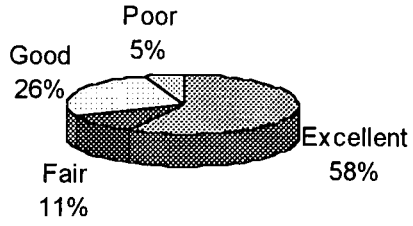

There are convenient means to search for a patient
Good 26%
Excellent 58%
Fair 16%


The system provides for all the basic clinical services rendered by a GP
Non-existent 5%
Poor 5%
Excellent 37%
Good 21%
Fair 32%

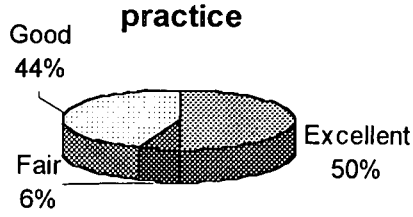

The system corresponds closely to the old way of doing things
Poor 10%
Excellent 15%
Fair 30%
Good 45%


The system is an improvement on the manual system
Poor 5%
Excellent 26%
Good 37%
Fair 32%

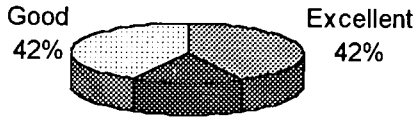
The system ensures that the entered data are valid to the greatest possible extent



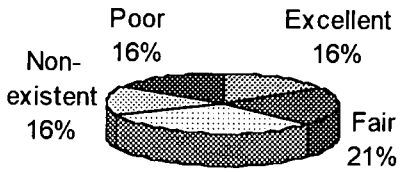
The system provides me with sufficient information regarding the clinical records in my practice



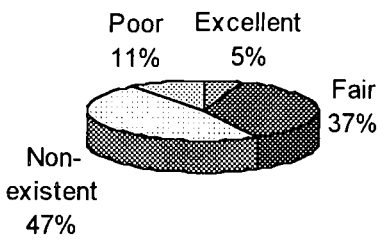
The system provides for the total medical record



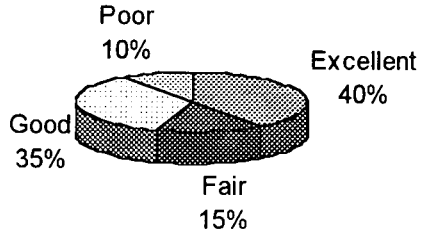
The system provides for too much detail



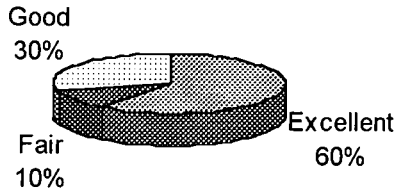
The system provides for too little detail



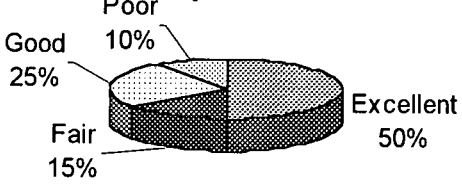
It is easy to find what I need to do in the system



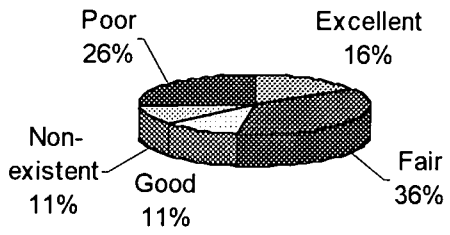
It is easy to move among the different screens



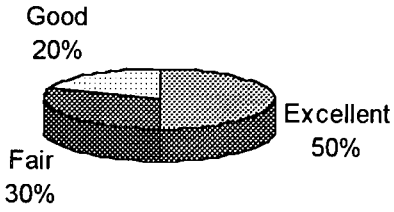
The system provides me with adequate freedom and does not force me to follow predefined sequences



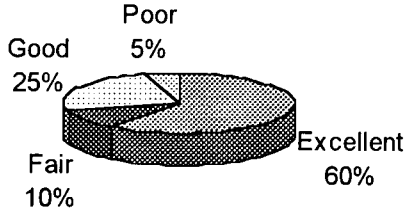
The amount of typing I need to do is acceptable



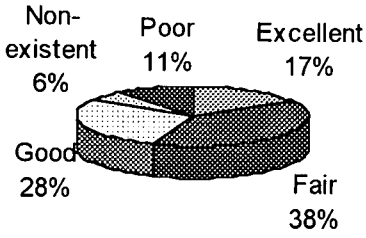
The interaction with the system is clear and understandable

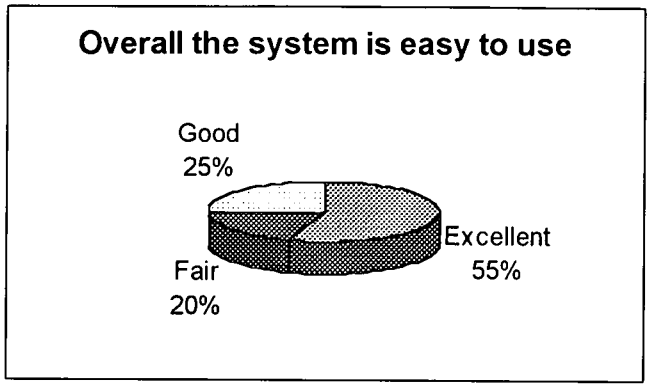


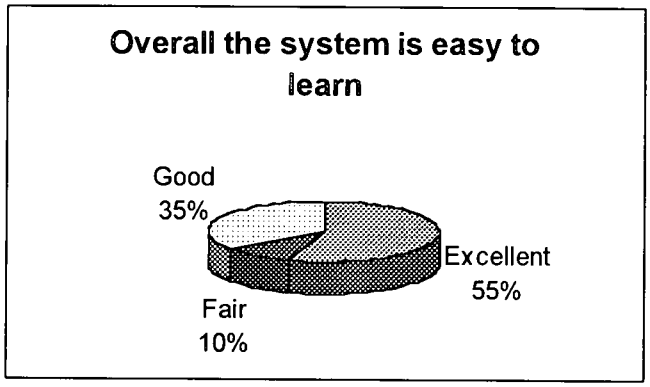
The user interface is visually well organised and is acceptable

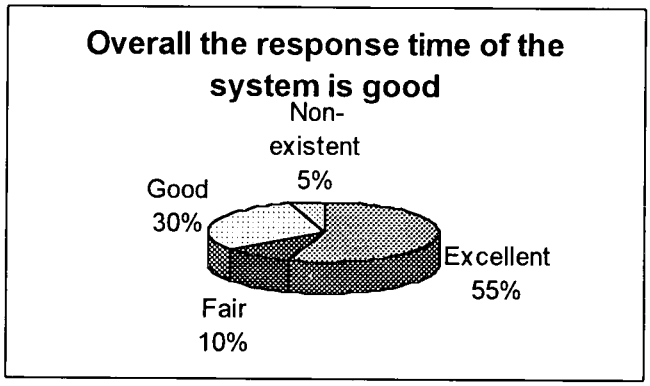


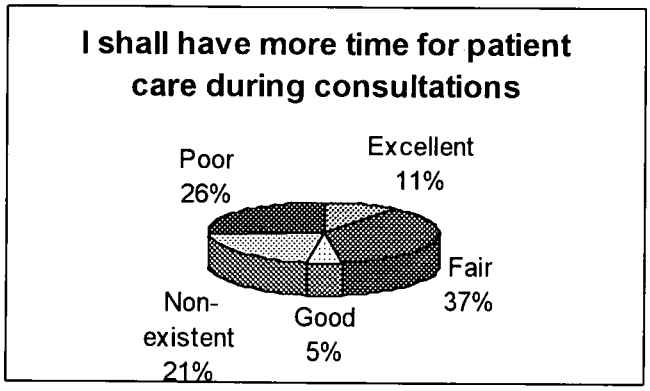
My productivity will increase by using the system

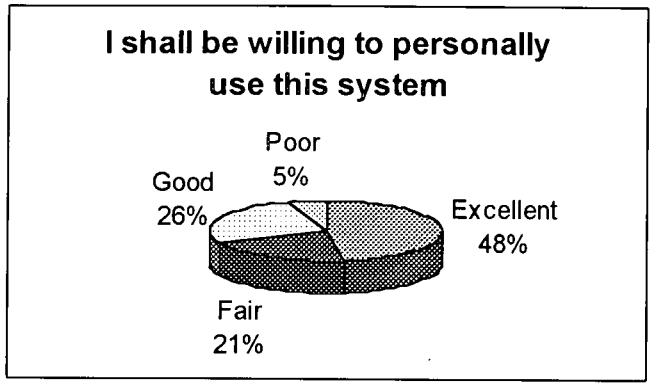


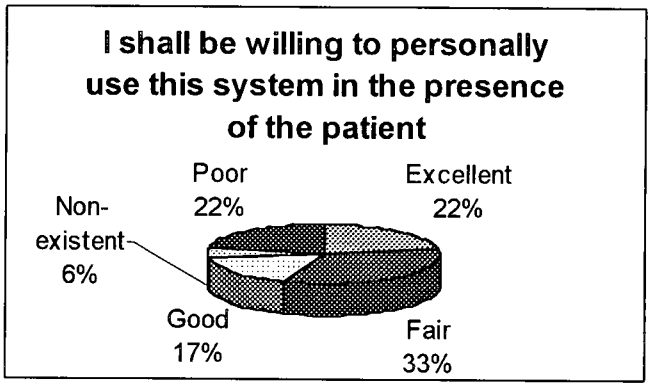

Overall the system is easy to use
Good
25%
Excellent
55%
Fair
20%

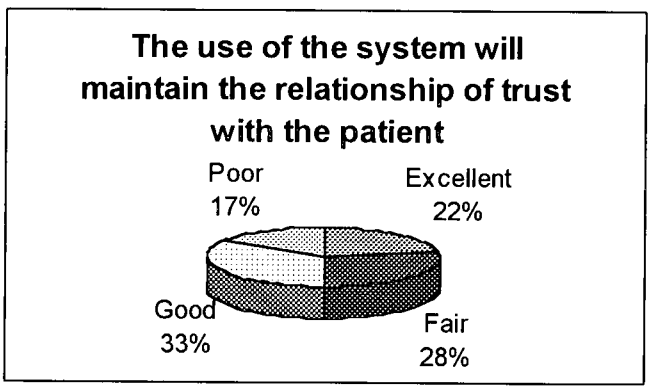

Overall the system is easy to learn
Good
35%
Excellent
55%
Fair
10%

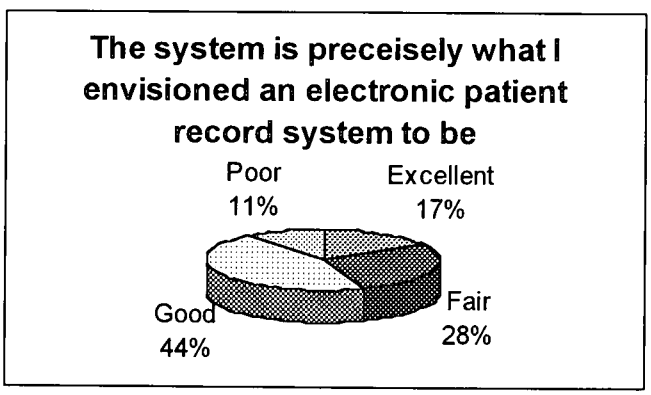

Overall the response time of the system is good
Non-existent
5%
Good
30%
Excellent
55%
Fair
10%

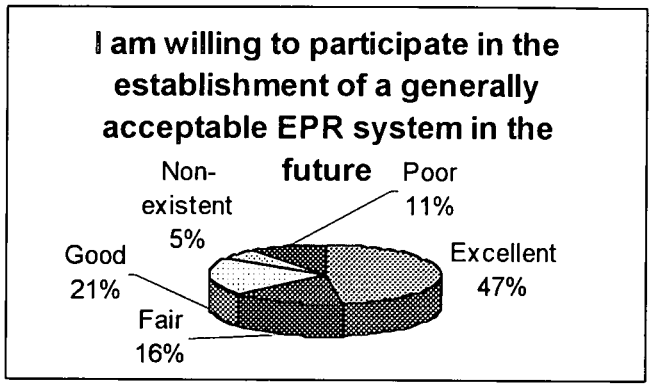

I shall have more time for patient care during consultations
Poor
26%
Excellent
11%
Fair
37%
Non-existent
21%
Good
5%


I shall be willing to personally use this system
Poor 5%
Good 26%
Excellent 48%
Fair 21%


I shall be willing to personally use this system in the presence of the patient
Poor 22%
Excellent 22%
Non-existent 6%
Good 17%
Fair 33%


The use of the system will maintain the relationship of trust with the patient
Poor 17%
Excellent 22%
Good 33%
Fair 28%


The system is preceisely what I envisioned an electronic patient record system to be
Poor 11%
Excellent 17%
Good 44%
Fair 28%


I am willing to participate in the establishment of a generally acceptable EPR system in the future
Non-existent 5%
Poor 11%
Good 21%
Excellent 47%
Fair 16%

Appendix N

Empirical test data

NUMBER OF TIMES THAT THE USER ASKED FOR ASSISTANCE				
Subject	**Presentation order**	**First**	**Second**	**Sign**
1	FS	0.00	0.00	0
2	FS	1.00	1.00	0
3	FS	2.00	0.00	+
4	FS	4.00	3.00	+
5	FS	3.00	1.00	+
6	SF	2.00	1.00	+
7	SF	0.00	0.00	0
8	SF	1.00	0.00	+
9	SF	3.00	2.00	+
10	SF	1.00	1.00	0
mean		**1.70**	**0.90**	
s.d.		**1.34**	**0.99**	
n		**10.00**	**10.00**	
95% CI		**0.83**	**0.61**	

NUMBER OF TIMES THAT THE USER EXPRESSED FRUSTRATION				
Subject	**Presentation order**	**First**	**Second**	**Sign**
1	FS	0.00	0.00	0
2	FS	1.00	1.00	0
3	FS	1.00	0.00	+
4	FS	2.00	0.00	+
5	FS	1.00	1.00	0
6	SF	1.00	0.00	+
7	SF	0.00	0.00	0
8	SF	0.00	0.00	0
9	SF	2.00	1.00	+
10	SF	1.00	0.00	+
mean		**0.90**	**0.30**	
s.d.		**0.74**	**0.48**	
n		**10.00**	**10.00**	
95% CI		**0.46**	**0.30**	

NUMBER OF TIMES THAT A MESSAGE APPEARS IN THE STATUS LINE				
Subject	**Presentation order**	**First**	**Second**	**Sign**
1	FS	9.00	11.00	+
2	FS	9.00	12.00	+
3	FS	11.00	12.00	+
4	FS	12.00	11.00	-
5	FS	11.00	14.00	+
6	SF	12.00	11.00	-
7	SF	12.00	11.00	-
8	SF	10.00	11.00	+
9	SF	11.00	11.00	**0**
10	SF	9.00	11.00	+
mean		**10.60**	**11.50**	
s.d.		**1.26**	**0.97**	
n		**10.00**	**10.00**	
95% CI		**0.78**	**0.60**	

TIME SPENT ON ERRORS				
Subject	**Presentation order**	**First**	**Second**	**Sign**
1	FS	12.00	2.00	+
2	FS	8.00	0.00	+
3	FS	3.00	10.00	-
4	FS	20.00	3.00	+
5	FS	15.00	9.00	+
6	SF	25.00	5.00	+
7	SF	0.00	0.00	**0**
8	SF	10.00	4.00	+
9	SF	65.00	43.00	+
10	SF	20.00	8.00	+
mean		**17.80**	**8.40**	
s.d.		**18.33**	**12.66**	
n		**10.00**	**10.00**	
95% CI		**11.36**	**7.85**	

NUMBER OF ERRORS				
Subject	**Presentation order**	**First**	**Second**	**Sign**
1	FS	9.00	3.00	+
2	FS	2.00	0.00	+
3	FS	2.00	2.00	0
4	FS	4.00	2.00	+
5	FS	4.00	2.00	+
6	SF	2.00	1.00	+
7	SF	0.00	0.00	0
8	SF	1.00	1.00	0
9	SF	6.00	2.00	+
10	SF	3.00	1.00	+
mean		**3.30**	**1.40**	
s.d.		**2.63**	**0.97**	
n		**10.00**	**10.00**	
95% CI		**1.63**	**0.60**	

NUMBER OF TIMES WHERE ENTER WAS PRESSED INSTEAD OF TAB				
Subject	**Presentation order**	**First**	**Second**	**Sign**
1	FS	0.00	0.00	0
2	FS	0.00	1.00	-
3	FS	1.00	0.00	+
4	FS	0.00	0.00	0
5	FS	1.00	1.00	0
6	SF	3.00	2.00	+
7	SF	0.00	0.00	0
8	SF	2.00	1.00	+
9	SF	0.00	0.00	0
10	SF	2.00	2.00	0
mean		**0.90**	**0.70**	
s.d.		**1.10**	**0.82**	
n		**10.00**	**10.00**	
95% CI		**0.68**	**0.51**	

NUMBER OF TIMES THAT THE USER IS PROHIBITED FROM FOLLOWING A STEP/PATH				
Subject	**Presentation order**	**First**	**Second**	**Sign**
1	FS	2.00	0.00	+
2	FS	0.00	0.00	0
3	FS	1.00	0.00	+
4	FS	2.00	0.00	+
5	FS	4.00	1.00	+
6	SF	1.00	0.00	+
7	SF	0.00	0.00	0
8	SF	1.00	0.00	+
9	SF	2.00	0.00	+
10	SF	2.00	0.00	+
mean		**1.50**	**0.10**	
s.d.		**1.18**	**0.32**	
n		**10.00**	**10.00**	
95% CI		**0.73**	**0.20**	

NUMBER OF TIMES WHERE KEYBOARD-USE WAS ATTEMPTED IN VAIN				
Subject	**Presentation order**	**First**	**Second**	**Sign**
1	FS	0.00	0.00	0
2	FS	0.00	1.00	-
3	FS	0.00	0.00	0
4	FS	2.00	0.00	+
5	FS	0.00	0.00	0
6	SF	0.00	0.00	0
7	SF	0.00	0.00	0
8	SF	1.00	0.00	+
9	SF	0.00	0.00	0
10	SF	2.00	0.00	+
mean		**0.50**	**0.10**	
s.d.		**0.85**	**0.32**	
n		**10.00**	**10.00**	
95% CI		**0.53**	**0.20**	

NUMBER OF TIMES WHERE THE SYSTEM ASKED FOR CONFIRMATION				
Subject	**Presentation order**	**First**	**Second**	**Sign**
1	FS	2.00	4.00	+
2	FS	2.00	3.00	+
3	FS	2.00	4.00	+
4	FS	2.00	4.00	+
5	FS	2.00	4.00	+
6	SF	2.00	4.00	+
7	SF	2.00	4.00	+
8	SF	2.00	4.00	+
9	SF	3.00	4.00	+
10	SF	2.00	4.00	+
mean		**2.10**	**3.90**	
s.d.		**0.32**	**0.32**	
n		**10.00**	**10.00**	
95% CI		**0.20**	**0.20**	

NUMBER OF TIMES WHERE OUTPUT ON TABLES WERE USED FOR INPUT				
Subject	**Presentation order**	**First**	**Second**	**Sign**
1	FS	5.00	4.00	-
2	FS	5.00	4.00	-
3	FS	6.00	4.00	-
4	FS	4.00	5.00	+
5	FS	5.00	5.00	**0**
6	SF	4.00	4.00	**0**
7	SF	4.00	4.00	**0**
8	SF	5.00	4.00	-
9	SF	6.00	4.00	-
10	SF	6.00	4.00	-
mean		**5.00**	**4.20**	
s.d.		**0.82**	**0.42**	
n		**10.00**	**10.00**	
95% CI		**0.51**	**0.26**	

NUMBER OF TIMES WHERE THE USER WOULD WANT OPTIONS/DIFFERENT VALUES				
Subject	**Presentation order**	**First**	**Second**	**Sign**
1	FS	0.00	0.00	**0**
2	FS	1.00	0.00	**+**
3	FS	1.00	2.00	**-**
4	FS	0.00	3.00	**-**
5	FS	4.00	4.00	**0**
6	SF	1.00	1.00	**0**
7	SF	0.00	0.00	**0**
8	SF	1.00	1.00	**0**
9	SF	2.00	1.00	**+**
10	SF	1.00	0.00	**+**
mean		**1.10**	**1.20**	
s.d.		**1.20**	**1.40**	
n		**10.00**	**10.00**	
95% CI		**0.74**	**0.87**	

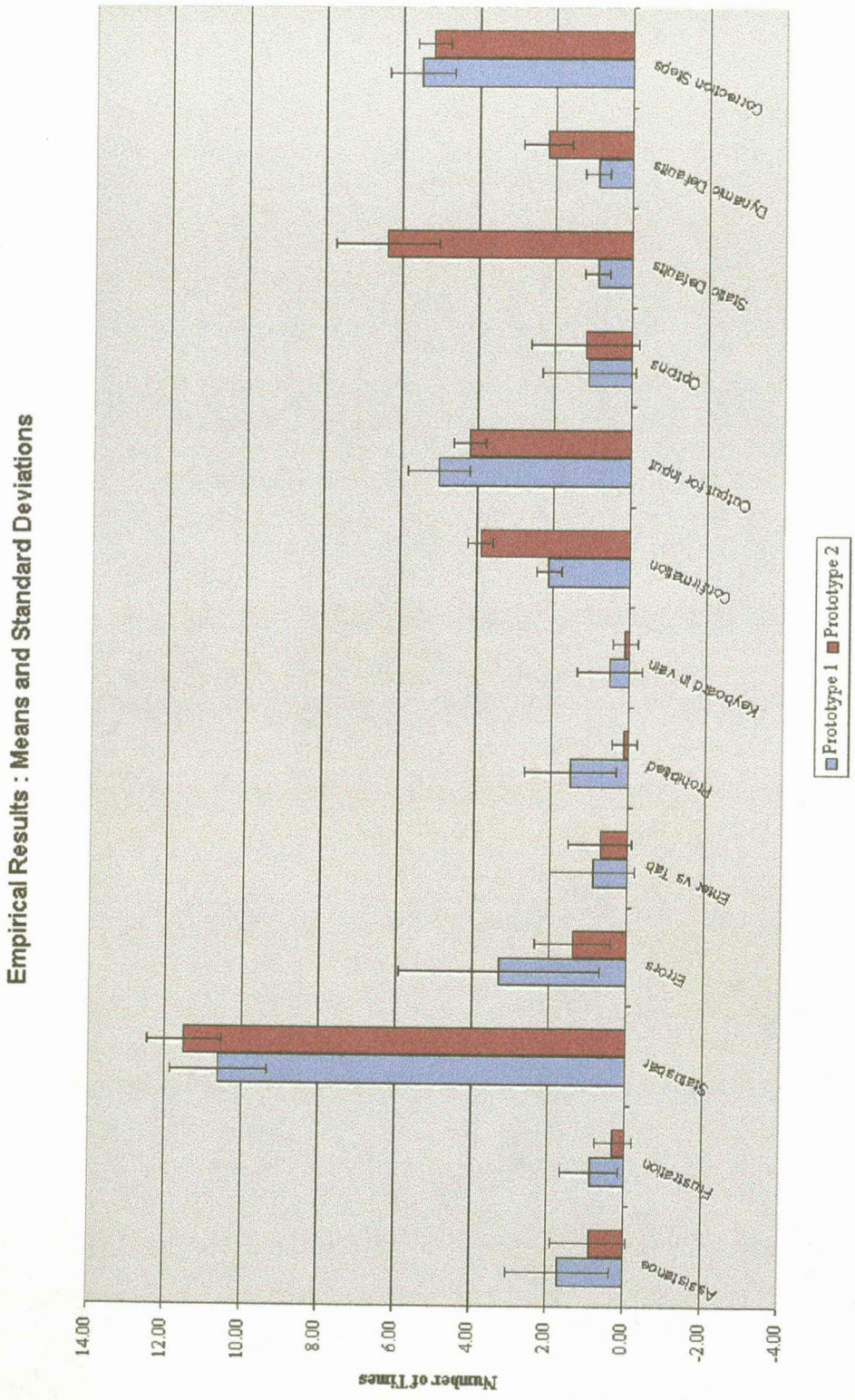
NUMBER OF STATIC DEFAULT VALUES ON THE SCREEN				
Subject	**Presentation order**	**First**	**Second**	**Sign**
1	FS	1.00	5.00	**+**
2	FS	0.00	5.00	**+**
3	FS	1.00	9.00	**+**
4	FS	1.00	5.00	**+**
5	FS	1.00	5.00	**+**
6	SF	1.00	7.00	**+**
7	SF	1.00	7.00	**+**
8	SF	1.00	7.00	**+**
9	SF	1.00	7.00	**+**
10	SF	1.00	7.00	**+**
mean		**0.90**	**6.40**	
s.d.		**0.32**	**1.35**	
n		**10.00**	**10.00**	
95% CI		**0.20**	**0.84**	

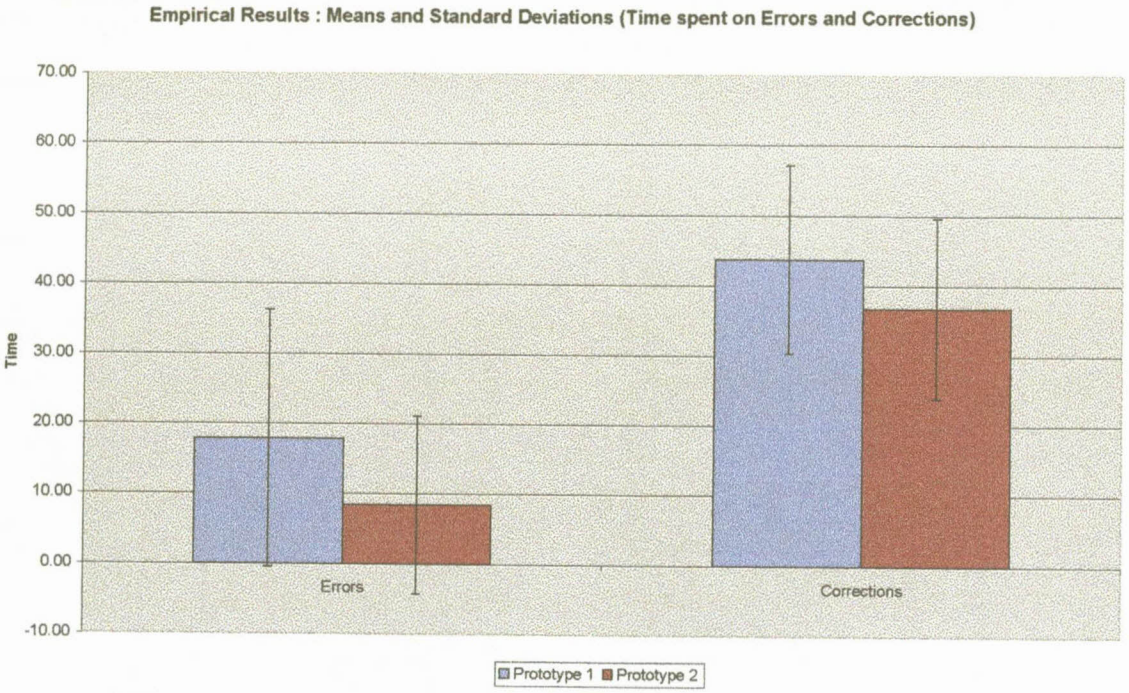
NUMBER OF DYNAMIC DEFAULT VALUES ON THE SCREEN				
Subject	**Presentation order**	**First**	**Second**	**Sign**
1	FS	1.00	4.00	+
2	FS	1.00	2.00	+
3	FS	1.00	2.00	+
4	FS	1.00	2.00	+
5	FS	1.00	2.00	+
6	SF	1.00	2.00	+
7	SF	0.00	2.00	+
8	SF	1.00	2.00	+
9	SF	1.00	2.00	+
10	SF	1.00	2.00	+
mean		**0.90**	**2.20**	
s.d.		**0.32**	**0.63**	
n		**10.00**	**10.00**	
95% CI		**0.20**	**0.39**	

TIME DURATION TO MAKE A CORRECTION				
Subject	**Presentation order**	**First**	**Second**	**Sign**
1	FS	39.00	39.00	**0**
2	FS	38.00	40.00	-
3	FS	60.00	45.00	+
4	FS	30.00	26.00	+
5	FS	51.00	41.00	+
6	SF	54.00	42.00	+
7	SF	20.00	12.00	+
8	SF	42.00	38.00	+
9	SF	63.00	59.00	+
10	SF	40.00	25.00	+
mean		**43.70**	**36.70**	
s.d.		**13.41**	**12.88**	
n		**10.00**	**10.00**	
95% CI		**8.31**	**7.98**	

NUMBER OF STEPS NECESSARY TO MAKE CORRECTIONS				
Subject	**Presentation order**	**First**	**Second**	**Sign**
1	FS	6.00	5.00	+
2	FS	5.00	6.00	-
3	FS	5.00	5.00	0
4	FS	5.00	5.00	0
5	FS	7.00	5.00	+
6	SF	5.00	5.00	0
7	SF	5.00	5.00	0
8	SF	5.00	5.00	0
9	SF	7.00	6.00	+
10	SF	5.00	5.00	0
mean		**5.50**	**5.20**	
s.d.		**0.85**	**0.42**	
n		**10.00**	**10.00**	
95% CI		**0.53**	**0.26**	

Graphical representation of empirical results




Empirical Results : Means and Standard Deviations (Time spent on Errors and Corrections)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
-10.00
Time
Errors
Corrections
Prototype 1
Prototype 2

ppendix O

ublications and articles submitted for publication

he Electronic Patient Record in General Practice - A South-African Perspective

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stract

esearch project was undertaken to design an electronic dical record system which will cater for the specific eds of South African general practitioners and their ique requirements. The project was launched by sending t a questionnaire to general practitioners in the Free te, trying to determine their specific requirements and to n insight into their attitudes and opinions regarding the e of computers, especially the computer-based patient ord, in a general practice setting. The results indicated t there was a need to replace the current manual patient ord with an electronic version, and that the attitudes of general practitioners in South Africa were generally ourable regarding implementing and using such a tem. Given these results, we can proceed to design a nputer-based patient record system, specifically dressing the needs and requirements of the South African neral practitioner.

ywords:

per medical record; Computer-based patient record; neral practice

troduction

medical record is a confidential record that is kept for h patient by a health care professional or organisation. It tains the patient's personal details (such as name, ress, date of birth), a summary of the patient's medical tory, and documentation of each event, including mptoms, diagnosis, treatment and outcome. Relevant uments and correspondence are also included. The main pose of the medical record is to provide a summary of a son's contact with a healthcare provider and treatment vided to ensure appropriate healthcare"[1].

proximately a quarter of a century ago, researchers an to draw attention to the shortcomings of the paper dical record (PMR). This was due to, among other reasons, the poor organisation, incompleteness, and inaccuracy of the PMR. The increased complexity of health care and information demand, combined with the potential of computer technology, has led to a great enthusiasm for and high expectations of applying that technology to computerise the patient record. Yet, even after 25 years, with some exceptions for primary care, there is still no computer-based patient record (CPR) in wide-spread use that fully replaces the paper chart. It has been stated that, apparently, for physicians, the potential benefits of the CPR do not yet outweigh the strengths of the PMR [2].

In undertaking this research project, the authors proposed to proof the contrary. We believe strongly that the potential benefits of the CPR do indeed outweigh the strenghts of the PMR. Proving that general practitioners in South Africa also see the potential benefits, would give us the go-ahead to design a prototype(s) CPR system to fulfil the specific needs and requirements of general practice.

Materials and Methods

Before designing a specific prototype/system, it was deemed absolutely necessary to gain insight into the physicians' opinions regarding the role of the computer in a general practice. In order to gain this insight, a questionnaire was designed which broadly covered the following sections: General Information, Manual System, Use of the Computer System, Problems with/Objections against Computer-based Patient Records, and in conclusion, General Opinions regarding the Possible Success/Failure of the Use of Electronic Medical Records in General Practice.

It was decided to use the Free State Province (a province roughly in the centre of the Republic of South Africa) as the population, because the needs in the Free State should not differ substantially from the other provinces in the country. A random sample of 150 was drawn from all the practising general practitioners in the Free State and was sent out in January 1997. Of these original 150 questionnaires, 48 were

turned by mid-February. As a result of the fact that the ly list of practising general practitioners we could attain, as a bit outdated, only 37 of this 48 responses could be ed. The other eleven was irrelevant, because the actitioners were either hospital appointments, had already tired or are specialising at present.

fter telephone follow-ups in February and March, 79 estionnaires were returned in total, of which 56 could be ed (for the same reasons as mentioned above). As 23 of e total of 79 questionnaires received could not be ssified as being the opinions of general practitioners, the iginal sample of 150 shrunk to 127. This brought the sponse to 44%.

esults

e results, after coding and processing the questionnaires, summarised according to the different sections of the estionnaire.

neral Information

% of the general practitioners taking part in the study, licated that they are engaged in a one-man practice, while others are engaged in either a partnership or an ociation. The maximum number of years in general actice was 47, while the mean was 6 years and the nimum 1 year.

computer is used in 93% of the respondents' practices, ile 7% have no computer technology available to assist their practices. Of those respondents using a computer, % currently use their computer for administrative rposes, 7% for dispensing, 6% for clinical purposes, and for other purposes, for example for electronic data erchange (EDI) and stock control.

the question whether or not they were satisfied with the tems currently in use, 92% of the respondents replied itively. Being a very important pre-condition for the cess of CPRs, 67% of the practitioners indicated that y personally use the computer systems. Sixty five cent indicated that their receptionists use their systems, % that the systems are being used by clerical personnel, 31% by an accountant.

nual System

garding the current manual system in use in their ctices, 63% indicated that they have a written task cription/explanation of these systems, while 37% did The SOAP-scheme (Subjective, Objective, essment, Plan) is the scheme being used by 92% of the ctitioners to record the clinical information, while the ance of 8% do not use a specific format. Similarly the m head to toes" framework/scheme is used by 82% of practitioners, while the other 18% also indicated that they do not use a specific format.

A very important aspect regarding the possible future success of the CPR were addressed by the question "Which of the following usually applies to you when you record the clinical information of the patient?". Sixty percent of the respondents indicated that notes were made in the presence of the patient, 35% that notes were made partly in the presence of the patient and partly as soon as he/she has left the room, 4% that notes were made as soon as the patient left the consulting rooms, and 2% that notes were made at the end of each day.

Addressing the problems that general practitioners experience with their current manual systems (which are the aspects which a CPR should try and resolve), the problems in Table 1 were highlighted.

Additional purposes for which existing clinical manual records are used, include the drawing of statistics for personal information and for the sake of interest (27%), reminders of follow-up visits (20%), determining of health risks e.g. to determine a patient's chance of having a heart attack (16%), research regarding general partitioning (6%).

Table 1 – Problems associated with current manual systems

Problems	Physicians	% of total
Mis-filed files	32	62
Recording of external work	24	46
Separate clinical & financial systems	22	42
Time consuming	18	35
Lost files	17	33
Identifying old, unused records	16	31
Incompleteness of medical record as a whole	15	29
Durableness of records	13	25
Transferability of records	12	23
Filing reports/x-rays	11	21
Delays in handling specialist/lab reports	11	21
Duplication	7	14
Illegible/incomprehensible	6	12
Immediate recording of patient' visit	5	10
Not adaptable to changing circumstances	5	10
Unpractical format	4	8
Disorganised, files become too thick, storage of files becomes problem	3	6

Use of the Computer System

Moving on to questions regarding the use of a computer system, 55% of the respondents indicated that they would still prefer to have a printed copy of their patient's record if

ey should change to a computerised clinical record stem. Reasons given included that a backup for the mputer system was needed (43%), it is convenient to ve everything close by and to have a paper copy for ference purposes (24%). Of the 45% respondents dicating that they do not prefer to have a printed copy of e patient's record, the reasons given were that they only eded a paper copy on request (22%), a paper copy would necessary increase costs (56%), and that a paper copy uld necessitate an extra filing system.

sked about their attitudes towards the use of a computer in e presence of the patient during the consultation, the sponse varied with the majority (27%) feeling neutral out it, 25% being totally positive, 23% being moderately sitive, 16% being moderately negative, and only 9% ing totally negative. Those respondents feeling totally or derately negative about using the computer in the esence of the patient during the consultation, are nvinced that the patient should have the undivided ention of the practitioner, that the patient might feel like number on a piece of paper (impersonal), and that the actitioner will still keep paper notes.

me of the more important motivational factors for those o are moderately or totally positive inclined, are that the actitioner would prefer a pre-programmed questionnaire ere he/she only have to make choices, when the patient ves the consulting room everything (consultation, count) is concluded, CPR is seen as being fast, correct d ordered, the CPR will demonstrate the thoroughness of practitioner, all records will be available, and that the mputer is already being used in the presence of patients h great success.

ing asked in which instances the computer could be used h success in the presence of a patient, calling up a ient's medical record got the best support (86%), lowed by dispensing (73%), administrative /financial lications (71%), part of the clinical examination (46%), l for statistical/graphical information (29%).

garding the question of the preferred methods for ering information into the computer in the presence of patient, using the mouse was the most popular (50%), lowed by typing from the keyboard (44%), speech %), a touch screen (24%), and a light pen (9%).

he case where a computer system were to be used during clinical examination, 66% of the physicians preferred to er the information immediately in the presence of the ient, 21% preferred to make notes which they would er into the computer later on, 4% preferred to make es which the receptionist/clerical personnel can enter r on.

e of the known advantages of CPRs is better mmunication among the health services. Response to the stion asking with which parties the physician would like establish contact through the system, indicated that hologists and medical funds were the most popular ice (both 82%), with specialists and laboratories owing closely behind (73%). Radiologists (66%), other general practitioners and pharmacies (both 47%), and hospitals (36%) also received support.

Addressing the important aspect of the data model used for designing a CPR system, the following question was put to the respondents: "Are you in favour of a guideline-based computerised patient record system, i.e. a system based on systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances?". A substantial number of respondents, namely 78% indicated that they were in favour thereof, while 22% indicated that they weren't. Six respondents did not answer the question, which might indicate them not understanding the question.

Problems with/objections against computer-based patient records

One would not get an objective view of the opinions of general practitioners regarding the CPR if one did not dare asking what problems/objections they foresaw regarding the use/functioning of such a system, as well as with its use in general practice. Tables 2 and 3 represent the responses to these two questions.

General Opinions Regarding the Possible Success/Failure of the Use of Electronic Medical Records in General Practice.

The questionnaire was concluded with a few general questions regarding the possible success/failure of the use of electronic medical records in general practice. Asked which fields professional societies should contribute towards, 64% of the respondents felt that provision of guidelines for information in general practice was most important. This was followed by training of general practitioners in the use of information systems (58%), evaluation of existing computer systems (56%), negotiating partial compensation for system implementation with government (56%).

The Internet was also addressed in the questionnaire. Seventy three percent of the practitioners showed an interest in using the Internet, while 27% were not interested at all, reasons varying from lack of time, not important for good practising methods, lack of knowledge, to high costs. Those in favour of using the Internet, motivated their opinion with the fact that it opens an immediate "gateway" to international medicine.

Table 2 – Problems foreseen regarding the use/functioning of a computer-based patient record system

Problem	Number of physicians	% of total
Recording of work performed outside the consulting room	31	56
Problems in linking information (e.g. hand-written reports) with system	31	56

Relationship of trust with the patient	23	42
Process of change from a manual system	23	42
Computer tasks interfering with existing normal tasks	23	42
Immediate recording of a visit	17	31
Lack of general standards regarding standard clinical vocabulary	12	22
Resistance on the part of the patients	8	15
Changed working method	8	15
Lack of general standards regarding patient identification	4	7
Not adaptable to changing circumstances	2	4
Power failures in the country side and viruses	2	4

Table 3 – Problems foreseen with/objections against computer-based patient records in general practice

Problem	Number of physicians	% of total
Cost : Initial capital investment	34	61
Time : Duration of patient encounter	31	55
Computer illiteracy	26	46
Time : Training	24	43
Security	24	43
Time : Use of the system	19	34
Software	18	32
Ethics	16	29
Hardware	15	27
Cost : Operating cost	11	20
Quality of information	10	18
Personnel	9	16
Cost information, linking with other institutions	3	5
None of the above	1	2

sting the respondents' opinions regarding the possible cess of a CPR system, 91% were of the opinion that it be successful, while 9% believed the contrary. This was tivated mainly by a fear of the influence of computer teracy. Quite a number of reasons were given for giving CPR a fair chance on success, the most important sons being that the CPR is more organised, that success l depend on the software and operators, the record will ays be available, and that the implementation of the R will ease general practice keeping.

good CPR system were to be available, the respondents e asked whether or not they would use it. Ninety one cent replied positively, while the other 9% declined. se responding positively towards the principle, stated it would, however, depend on the cost and lementation.

Discussion

Given a response of 44%, one might argue that the questionnaire was completed by general practitioners who are positively inclined towards computers. Those who do not like computers, who are computer illiterate or who are sceptical about the use of computers in general practice, most probably constitute a substantial percentage of the 56% practitioners who did not respond. Looking at the distribution regarding the number of years in general practice, also indicates that most of the respondents are relatively young (mean of 6 years). These facts might indicate that the results of the processed questionnaires will be slightly biased towards computer-use. Of the 56 respondents, only 4 do not use a computer in their practices at all.

The sample is, however, well represented as far as the nature of the practices (one-man practice or partnership/association) are concerned. It is interesting to note that 50% of the respondents have urban-practices, while 50% have country-practices.

The results show that computer use in general practice in the Free State is limited to administrative purposes. The lack of integration with clinical records are therefore also one of the reasons given for not being satisfied with the system currently in use. Only 6% of the respondents indicated that their systems are used for clinical purposes also. All this shows that the design and implementation of CPR systems in the Free State, and therefore in South Africa, is a barren field with a lot of potential to explore.

To be successful, it is crucial that the practitioner will personally use a CPR system. The fact that 67% of the respondents indicated that that was the case with their current computer systems, may be a positive indication regarding the attitudes, willingness and computer literacy of general practitioners, which will be very important when implementing a CPR system.

Using their current manual clinical record systems, 60% of the practitioners indicated that they take notes in the presence of their patients. The conclusion can be made that this method would be preferable when using a CPR system as well.

The majority of attitudes towards using a computer in the presence of a patient, being neutral, moderately positive or totally positive, can be interpreted as a go-ahead in designing a CPR system. It should, however, be born in mind that the system should be designed in such a way that the practitioner will still be able to make the patient feel as if he/she is the most important person in the consulting room. The computer system should complement the consultation, rather than dictate the consultation. There are scepticism among practitioners regarding the use of a computer in the presence of the patient. This was illustrated by the response of only 46% towards using the computer as part of the clinical examination. This might be because of

ar of the unknown. Practitioners do not seem to have any oblem with using the computer in the presence of the tient to call up a medical record, for dispensing, or for lministration/financial applications. When given a uation where a computer is used as part of the clinical amination, it is positive to note that the practitioners uld prefer to enter the information immediately in the esence of the patient, as is the case with the use of their rrent manual systems.

ooking at the user interface of a CPR system, it is teresting to note that practitioners still prefer using a ouse and the keyboard. This would indicate a graphical er interface. There are, however, concern regarding the k of typing skills, and this should be taken into account. sed on the response received on the matter, mmunication channels with other health professionals is ust in a CPR system.

actitioners do foresee problems with the use/functioning CPR's.. Their main concerns revolve around practical plementation problems in changing from a manual to a mputer system. The main concern regarding CPR's in neral practice, is the initial capital investment. This is a ry important point, especially when considering the type computer system to develop. In order for a computer stem to be successful, it should be used, and therefore uld be affordable to the average general practitioner. e prospective system should be designed in such a way t the duration of the patient encounter would not nsiderably be influenced by it.

e fact that 91% of the respondents were of the opinion t a CPR can be successful, and that 91% of them licated that they would use such as system, if it were ilable, is enough motivation to start the daunting task of signing such a system.

nclusion

sending out the questionnaires, we wanted to determine ether a need for a CPR system existed in South Africa, l if it did what the requirements would be. The response he questionnaire gave us exactly that.

learned that the general practitioners in South Africa lised the need for implementing computers in their ctices. As is the case in many parts of the world, they do erience frustrating problems with their current manual tems. The computer systems currently used in general ctice, mainly focus on administrative duties, and there is eed to integrate these functions with clinical CPR's.

practitioners indicated that the type of system they uld consider implementing, should be graphically based, ng the mouse and keyboard (and in future, voice) for ering data, it should be able to handle images, scriptions, and should be able to facilitate mmunication to various other roll players in the health ustry. Despite the fact that there is concern about the patient not getting the practitioner's undivided attention, most practitioners felt that they would be able to use the computer in the presence of the patient, and that they would prefer to enter the clinical information immediately in the presence of the patient. The practitioners are also willing to use the computer systems personally, an aspect which is considered to be of the utmost importance for the success of the CPR.

Despite some problems that are foreseen, we are left with a clear impression that general practitioners believe in the concept of the CPR, that they definitely feel a need for it and that they would use it, when available. We can now progress towards designing a CPR system to try and fulfil the needs of general practitioners in South Africa.

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A Prototype Electronic Patient Record For General Practitioners in the RSA

Lizette de Wet, Theo McDonald, Gawie Pistorius

Abstract

Objective: **To design and develop a prototype electronic patient record (EPR) system for general practitioners (GPs) in South Africa. This should be done by obtaining their needs, requirements, and recommendations regarding such a system. The ultimate goal is to present GPs in South Africa with an EPR system that caters for their specific needs and will be widely acceptable and used.**

Methods: **Questionnaires were posted to 150 GPs in the Free State as part of a requirement analysis. On the basis of the results of this questionnaire, and in close co-operation with the Department of Family Medicine, a first prototype system was designed and developed. The prototype was then demonstrated to a group of GPs for evaluation.**

Results: **On the positive side the physicians indicated that they would definitely use such a system and expressed great enthusiasm for being part of the development process. The main problems indicated were that too much typing was required, and that the users did not want to move through too many screens per consultation.**

Conclusions: **There is a great need for an EPR system in SA. The evaluation of the first prototype provided valuable input that will be applied in the design of a second prototype in order to bring us closer to the ultimate EPR system for South African GPs.**

Background

About twenty-five years ago, researchers began to draw attention to the shortcomings of the paper medical record (PMR). This became necessary due to, among other reasons, misfiled, lost, incomplete and poorly organised PMRs.[1,2] These frustrating problems that physicians experienced, combined with the potential of computer technology and the increased complexity of health care, gave rise to high expectations and great enthusiasm for an electronic version of the patient record, now referred to as the electronic patient record (EPR).[3] Yet, even after a quarter of a century (with some exceptions in primary care), there is still no EPR system in widespread use that fully replaces the PMR. This is particularly true for South Africa.

In order to prove that there is a need for an EPR system among general practitioners in South Africa, a questionnaire was sent to 150 practising general practitioners in the Free State. Despite some problems that had been anticipated, the researchers were left with a clear impression (after processing the questionnaires) that general practitioners in South Africa believe in the concept of the EPR, that they definitely feel a need for it and that they would use it, when available.[4]

The issue to address at that stage, was whether to buy or develop an EPR system. With regard to work already done on EPR systems, the Netherlands have come a long way using computers in medical practices with the Elias system. Elias was a

pioneering system consisting of five modules, of which the patient record has been relatively successful. The reasons for the Netherlands' success lie in their unique circumstances, differing substantially from those in South Africa. Their general practices are not as intensive as is the case in South Africa. Professional societies play a major role by enforcing the evaluation of EPR systems, and the government has incentives for capital expenditure on EPR systems,[5] a possibility not liable to occur in our country in the near future!

The AIM system (Advanced Informatics in Medicine) is a system funded by the European Community. The purpose of this system is to promote research and the development of EPR systems across the borders of different countries in Europe.[6] As a result of the vast scope of the project, these concepts are not yet in general use throughout Europe.

In a discussion of the success of the FAMUS project (the implementation of a province-wide computerised network in Quebec), it was stated that practical problems still needed to be resolved before computerised medical records would be accepted in primary care offices. It was also stated that only if a computerised medical record system became a valued tool in patient care, would its data be accurate and up to date.[7]

The computerised medical record program, CLINIC, was specifically designed at the Ben-Gurion University of the Negev to be used on-line by healthcare professionals in a primary care clinic during a patient encounter. In analysing the

effectiveness and use of CLINIC, it was found that the program did not shorten the total mean encounter time, but that the lengths of the encounter components and record use did change. The physician's work style also changed from a "conversational pattern" (continuous data recording) to a "blocked pattern" (data entry at intervals).[8]

Our research showed that in South Africa, most computer systems in general practices are used for financial and administrative purposes only. The most popular of these systems are Mass, Medsolve, Medit, and Multidoc.[4]

After examining a few existing systems, it was concluded that most existing systems promise a Utopia. This implies state of the art, expensive multimedia technology. Taking our specific situation in South Africa into account, this seemed to be totally inappropriate and impractical, especially when financial matters are reviewed. An example of a state-of-the-art system that would simply fall outside the budget limits of the majority of South African GPs, is the Pathways Smart Medical Record, developed by HBO & Company. This system integrates medical knowledge with a graphical user interface environment in an attempt to provide support to clinicians during the care process.[9] Another example is HEALTH one, a Belgian product built on the fundamental concept that a patient record must be completely adaptable to the individual's case (in terms of content and structure).[10]

The results of examining existing systems led to the design and development of a first prototype EPR system, while taking into account the requirements obtained from the general practitioner questionnaire.

Methods

Decisions regarding the first prototype

The first prototype was designed in close co-operation with the Department of Family Medicine at the University of the Orange Free State. Detailed discussions were held in order to establish how medical records were presently kept and how to transfer that information to an electronic version. The designers decided to base the first prototype on the way current paper records were compiled. This implied that every consultation would be organised according to Weed's Subjective, Objective, Assessment, and Plan (SOAP) scheme.[11] This decision facilitated the discussions with the physicians, and gave them a reference point.

Computer systems analysts know that before a computer system can be developed, a model must be designed which, in turn, is based on a data structure. Three basic models have been developed for computerised medical records, namely the template model, the Hindsighted Practice Guideline Model, and the Foresighted Practice Guideline Model.[12] The template model is by far the most popular model, and the one the medical personnel involved in the study, understand best and prefer. This model implies fixed database fields with fixed lengths, as well as fields making provision for free text.

Additional prototypes might be needed in order to test the feasibility of using these extremes, namely a fixed format or a free-text format. Most general practitioners prefer a free-text format where they have the freedom to enter narrative into memo fields. They are adamant that they would not like to be limited or restricted, or forced to make a specific diagnosis. From a computer science point of view, using free text fields in abundance is not practical, as it makes tasks such as obtaining statistics extremely difficult, if not impossible. The challenge when using the template model for the first prototype, seemed to be the daunting task of finding the golden midway between these two extremes.

The Hindsighted Practice Guideline Model is arranged to allow the physician to choose a canned report on the basis of the diagnosis reached or procedure to be performed. The physician can then edit the note using word processor skills.[12] Therefore, the diagnosis is the starting point, and from there the physician works "backwards". This method has not proved to be successful in practice, and would therefore not be considered as a possible data model in this research project.

The Foresighted Practice Guideline Model (FPG) could be the data model for the second proposed prototype. This model involves an algorithmic set of decision tables placed in the order in which the steps of the physician-patient encounter occur. This is called Process Flow Management. Process Flow Management is a method for applying maximum Total Quality Management concepts to quality,

cost, supplies, prospective research and standard of care. This is the information the physician uses to interact with the patient and all the other services and departments involved. The FPG model is a create-a-note style rather than a template-style model. The model uses the Standard Practice Guideline Format, a data structure that allows each individual managed care company/institution to customise the medical record-keeping requirements for each health care package it designs.[12]

The first prototype was developed in a Windows environment using Borland C++ Builder, with the aid of a Paradox database. A graphical-based, form-fillin interaction style, combined with menus and direct manipulation aspects, was chosen for the user interface. The form-fillin interaction style facilitated the correlation between the manual and electronic versions of the records. The users can manipulate the screens by means of the keyboard and/or a mouse.

The Prototype

When signing on to the system, a username and password are required. When this information has been accepted, the user is brought to the screen where the family's information must be entered. This information has a direct bearing on the main member of the medical aid, and is required to enable the practice to send the account. All the dependants of the main member are listed on this screen. This gives the user an opportunity to select the specific patient for the current consultation, or to create a new record for a new patient. At this stage it is

important to note that the receptionist can enter the personal information on the Family and Patient screens before the patient enters the physician's consulting room.

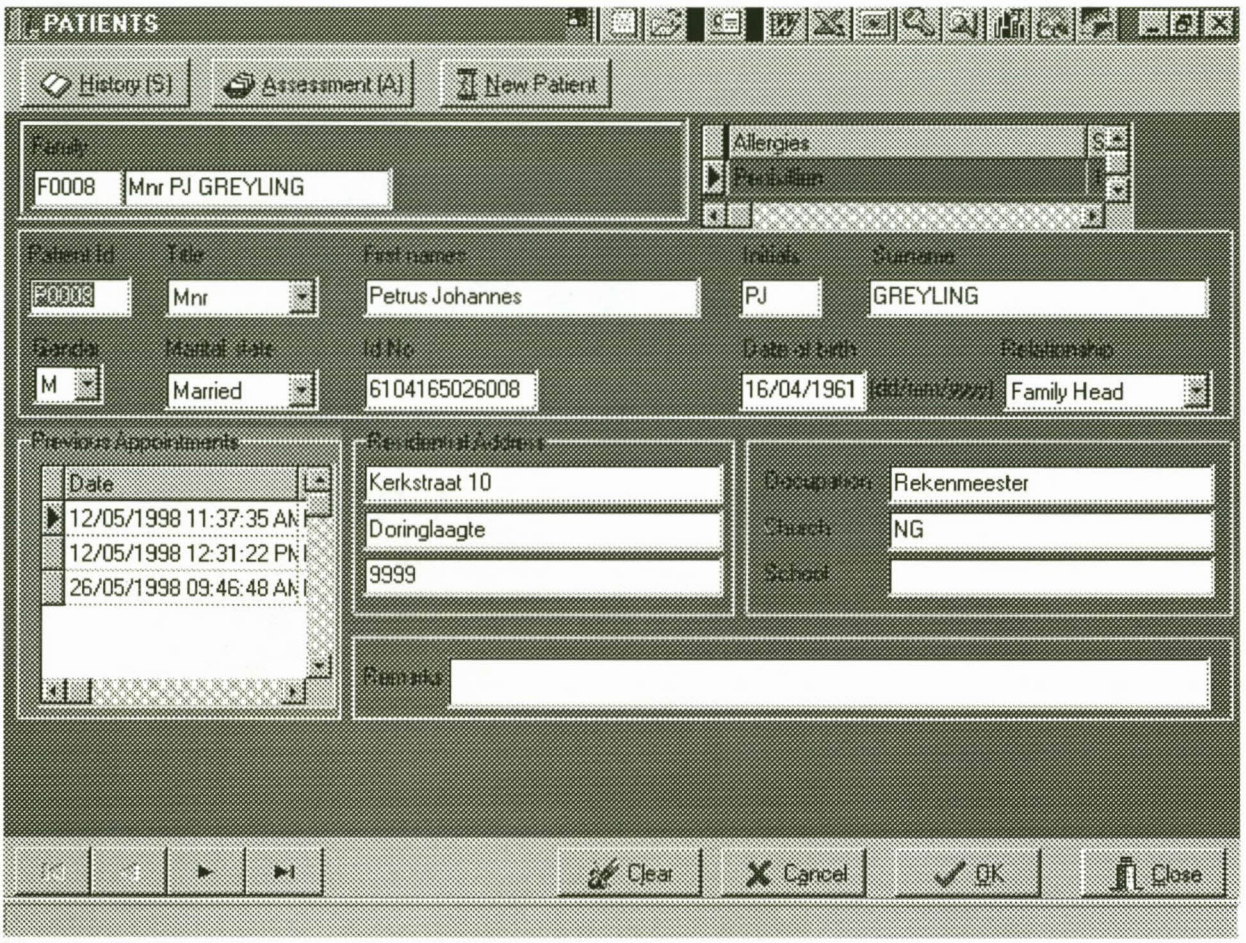


Fig. 1. Patient screen.

When presented with the patient information on the Patient screen (Fig. 1), a list appears indicating the dates and times of all the previous consultations of that specific patient. If the physician so requires, he/she can select one of the previous consultations and can then review the information pertaining to that consultation (Fig. 2). The physician also has the option to view the problem list of the patient, listing the problem numbers, problems with dates, and outcomes with dates (Fig. 3).

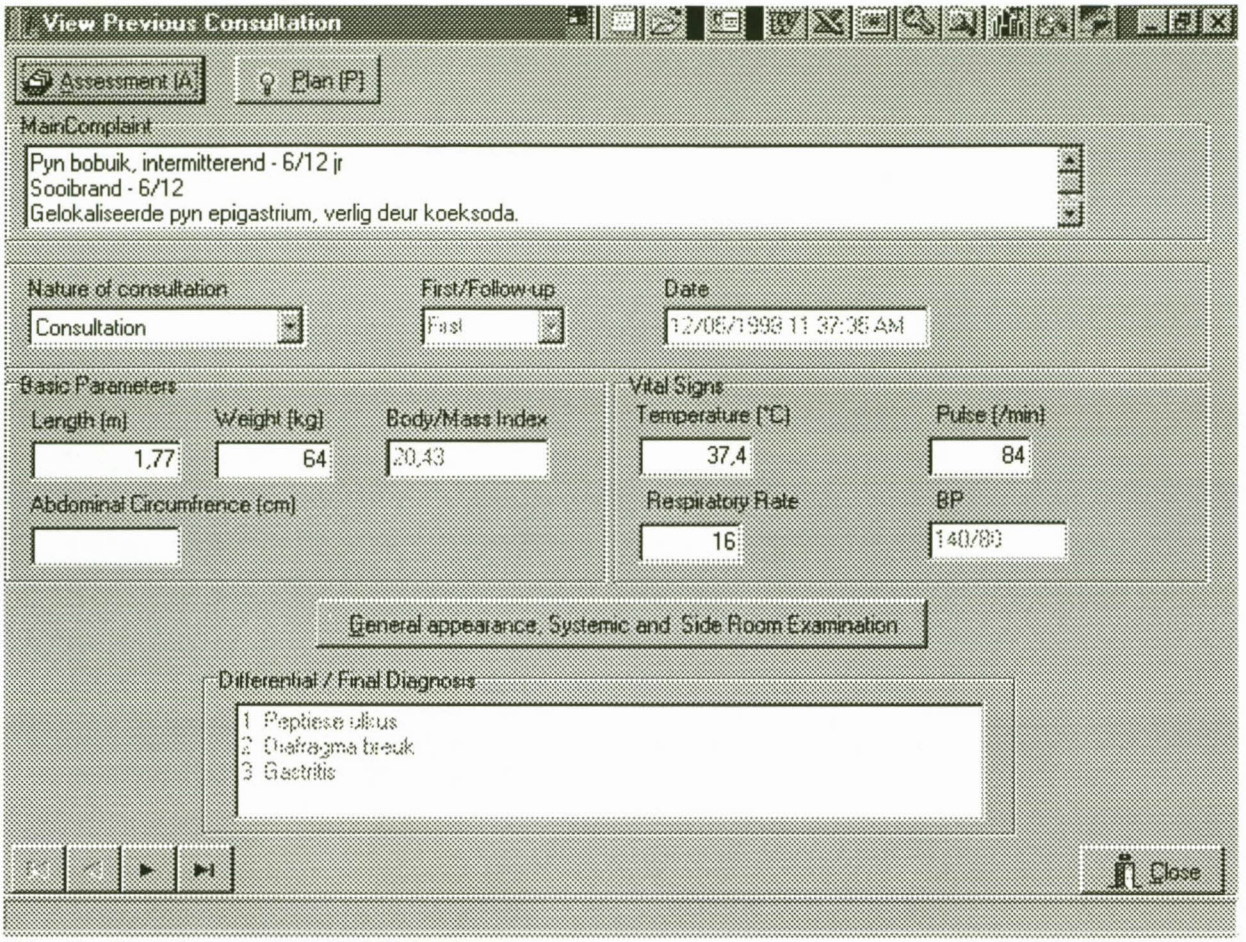


Fig. 2. Previous consultation screen.

As previously mentioned, every consultation is organised according to the SOAP scheme. When a new consultation has to be recorded, the user can start by pressing the History button. (This represents the "Subjective" part of SOAP.) On the history screen, the main complaint should be entered. The user can also view or add information regarding previous illnesses, operations, injuries, examinations, medicine and allergies. The Family History and General Profile are also addressed. The user can choose to view/enter information regarding the history of Systemic Examinations that makes provision for examinations of all body systems, from the Psyche to the Blood and RE System.

The Examination Screen (Objective) contains fields regarding the nature of the consultation, the basic parameters (e.g. length, weight, body mass index and abdominal circumference), and vital signs (e.g. temperature, pulse, respiratory rate, blood pressure). The screen provides information regarding the patient's

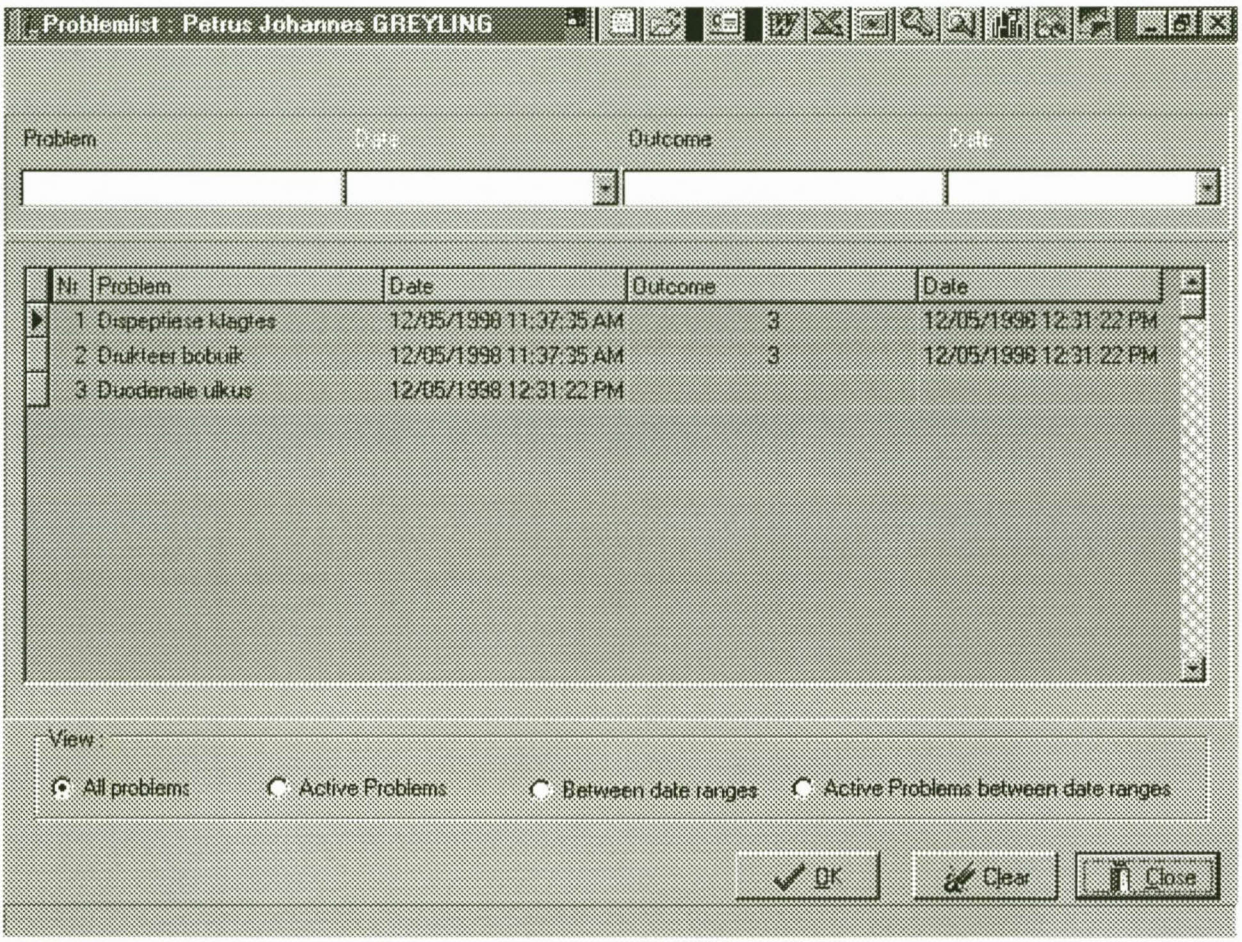


Fig. 3. Problem list screen

General Appearance (e.g. Jaundice, Anaemia and Cyanosis), Systemic Examination (regarding this specific consultation), and Side-room Examinations (e.g. hemoglobin or pregnancy test). New or existing problems can be addressed by clicking on the Assessment button to move to the problem list at any time during the consultation. The last section to be entered on the Examination screen before moving on to the Plan screen, is the Differential / Final diagnosis.

On the Plan screen, the physician can indicate the actions to be taken as a result of the consultation. This includes specific tests or examinations for which a patient can be referred, commonly known as Dx. The issuing of prescriptions, commonly known as Rx, and other instructions, referred to as Cx, are also catered for. Although the first prototype did not yet make provision for the dispensing function, the final system will definitely address this issue.

At this stage of entering the consultation information, the user has the option to revise any information entered regarding the specific consultation. Once the user is satisfied that the consultation has been properly recorded, the consultation is concluded. After this, the physician would not be able to change the record. As is the case with the manual system, any post-consultation changes should be made by means of a "minute method". Although the first prototype does not include a method for making these changes, the next prototype will provide the user with a screen where a specific consultation per patient can be selected, and any additional information regarding that consultation can be entered.

Evaluation

This first prototype was demonstrated to a group of about one hundred physicians during a course for general practitioners held by the Department of Family Medicine at the University of the Orange Free State on the 16th of May 1998. Each participant was handed an evaluation form. On a scale from 1 (non-existent) to 5 (excellent), the users had to rate certain aspects relating to the prototype.

Ample space was provided for additional comments, critique and recommendations. In the next section, the results of the processed evaluation forms will be discussed.

Results

The processed results of the evaluation forms gave the designers valuable information regarding the expectations practitioners have of an EPR system. Being confronted with an actual EPR system for the first time, most of the physicians now had the opportunity to visualise the use and impact of such a system. Being confronted with an EPR system in practice in comparison with a theoretical ideal, made it possible for physicians to come forward with practical advice, problems and recommendations.

Table 1 provides the results to the questions of the evaluation form. On a positive note, the physicians indicated that the system provided them with sufficient information regarding clinical records and made provision for the total medical record, that the interaction with the system is clear and understandable, the system is easy to learn, and that they would be willing to personally use the system. The fact that 81% indicated that they would be willing to participate in the establishment of a generally acceptable EPR system in future, gave a clear impression of the need and enthusiasm for, and belief in the possible success of such a system.

Taking the written comments, recommendations and critique into account, the most significant problems that were highlighted, were the following:

1. The system requires too much typing.
2. The user is confronted with too many screens in the performance of his task.

The fact that physicians require less typing, can be seen from the responses to the questions "The amount of typing I need to do is acceptable", "My productivity will increase by using the system", and "I shall have more time for patient care during consultations". These responses, together with the response to the question "It is easy to find what I need to do in the system", also indicate that there are too many screens.

Other concerns mentioned were the cost-factor, the possible jeopardisation of the relationship of trust between doctor and patient, confidentiality, the possibility of linking with existing financial systems, the use of a scanner to scan in specialist reports or images, and the future use of speech as an input method. A lot of reassurance can be given about these aspects when physicians are reminded of the status quo regarding current manual systems. Taking the issue of the relationship of trust as an example, the current manual systems would imply that the physician would put his / her pen down, look the patient straight in the eye, and hear the patient out while trying to determine the main complaint. Only after that would he/she start writing the clinical notes, in the presence of the patient. The situation need not differ substantially when using an EPR system for record-taking. The

same guidelines regarding the listening and eye contact apply, and after determining the main complaint, the physician would simply enter the information on the computer instead of writing a note. The precondition is that the computer should not be physically placed on the desk between the physician and the patient. It should be placed on a side table that the physician should be able to reach comfortably by simply rotating his / her chair.

Conclusions

What did the designers learn from this experience and how can this knowledge be applied? The specifications for the second prototype were greatly enhanced by the feedback received from the general practitioners. The second prototype, based on the basic principles of the first prototype, should supply the user with adequate means of reducing typing. This would accommodate the computer-illiterate user and would also save precious time when entering information regarding a consultation. The perception of moving through too many screens can be addressed by basing the user interface on the tab method. At a glance, the user would be able to see all the possible screens/options available, and would have the freedom to choose the order in which the consultation information is to be entered, according to personal preferences. By complying with these conditions and using the feedback received on minor issues regarding the system, a major step can be taken in order to present general practitioners in South Africa with an electronic patient record system which will greatly enhance the functioning and utilisation of their practices.

Table 1. Results of prototype evaluation.

Evaluation Question	Non-existent(%)	Poor (%)	Fair (%)	Good (%)	Excellent (%)
The task of registering a family is easy		3	14	51	32
There are convenient means to search for a family		2	8	49	41
The task of registering a new patient is easy.		2	10	47	41
There are convenient means to search for a patient.			8	44	48
The system provides for all the basic clinical services rendered by a general practitioner.		3	28	43	26
The system corresponds closely to the old way of doing things.	9	14	26	37	14
The system ensures that the entered data are valid to the greatest possible extent.		4	9	62	25
The system provides me with sufficient information regarding the clinical records in my practice.		2	19	45	34
The system provides for the total medical record.		3	27	32	38
It is easy to find what I need to do in the system.		3	33	38	26
The amount of typing I need to do is acceptable.	5	28	36	22	9
The interaction with the system is clear and understandable.		5	34	36	25
My productivity will increase by using the system.		26	38	18	18
Overall the system is easy to use.	2	8	31	42	17
Overall the system is easy to learn.			31	52	17
Overall the response time of the system is good.	2	9	26	44	19
I shall have more time for patient care during consultations.	3	41	38	16	2
I shall be willing to personally use this system.	2	5	25	32	36
I shall be willing to personally use this system in the presence of the patient.	11	12	30	26	21
The use of the system will maintain the relationship of trust with the patient.		17	38	31	14
This system is precisely what I envisioned an electronic patient record system to be.	3	9	36	42	10
I am willing to participate in the establishment of a generally acceptable electronic patient record system in the future.	5	2	12	31	50

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The Evaluation of two EPR Prototype Systems

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Abstract

In a joint venture undertaken by the Departments of Computer Science and Informatics and Family Medicine at the University of the Free State in Bloemfontein, South Africa, an attempt was made to present a model of an EPR system. This model was to be based on the specific needs and requirements as identified by South African general practitioners. In order to present this model, two EPR prototype systems were designed. These prototypes were evaluated in turn, where the results of the first prototype evaluation were applied in the design of the second prototype. The evaluation methods applied involved query techniques (questionnaires and evaluation forms), heuristic evaluation and usability testing. The latter included qualitative and quantitative (empirical) evaluations. A task analysis was also performed as part of the usability testing. The experienced gained as a result of these evaluation methods are thus presented as guidelines for the evaluation of prototype-developed systems.

Introduction

Information drives the practice of medicine. Unfortunately physicians drown in the amount of information engulfing their day-to-day tasks. The invention of the patient record was the first step in trying to bring order to this situation. Numerous problems are, however, experienced worldwide with the manual paper patient records that have been in use in medical practices for the past few years. The obvious answer to overcome these problems is an electronic patient record (EPR).

In South Africa (SA) the EPR is not generally used, despite its well-known potential advantages. Focussing on general practice, a research project therefore was jointly undertaken by the Departments of Computer Science and Informatics and Family Medicine at the University of the Free State in Bloemfontein, SA to:

- Ascertain whether a need for EPR systems exists
- Identify problems associated with current paper medical records
- Identify the requirements, expectations and needs regarding EPR systems
- Design and present prototype EPR systems for evaluation and testing by general practitioners (GPs) in SA according to their requirements, expectations and needs as mentioned above
- Present the GPs of SA with a model of a proposed EPR system, specifically designed for their requirements, expectations and needs.

The results of questionnaires that were sent out indicated that the GPs in SA realised the need for implementing computers in their practices. As in many parts of the world, they do experience frustrating

problems with their current manual systems. These include mis-filed and lost files, difficulty in recording external work, the identification of old, unused files, the durability and transferability of files, duplication, illegible/incomprehensible files that become too thick too fast and the physical storage space for these files. The computer systems currently used in general practice focus mainly on administrative and financial duties, and there is a need to integrate these functions with clinical EPR's. The GPs also gave an indication of the type of system they would consider implementing.

Despite some problems that were foreseen, a clear impression was left that GPs believed in the concept of the EPR, that they definitely felt a need for it and that they would use it (personally), when available.

Subsequently two prototype EPR systems were developed. The first prototype was based on the feedback received from the questionnaires sent to GPs as well as on the lessons learned from the development of EPR systems in the rest of the world. The first prototype was evaluated applying numerous evaluation methods. These evaluation results were then incorporated into the design of the second prototype, which was evaluated in a similar manner as the first prototype. Valuable experience was gained from the evaluation exercise. The evaluation methods will therefore be discussed in the next section. It is important to note that the emphasis will lie on the methods followed, and not on the specific results gained from these methods.

Methods

Evaluation has three main goals, namely [Dix 1998:406]:

- To assess the extent of the system's functionality
- To identify any specific problems with the system
- To assess the effect of the interface on the user.

In order to comply with the first and second goals, namely to assess the extent of the system's functionality and to identify any specific problems with the system, it was decided to use query techniques. To assess the effect of the interface on the user (evaluation goal number 3), a heuristic evaluation was first conducted by the designer. Usability testing in the form of a combination of observational techniques and empirical methods to gain qualitative as well as quantitative information regarding the interaction of actual users with the first prototype followed. A task analysis also formed part of the latter.

The discussion of the evaluation procedures under the headings of *Query techniques, Heuristic evaluation* and *Usability testing*, illustrates the author's own interpretation of evaluation method categorisation used here. The reason for mentioning this is that almost every textbook covering the topic of user interface evaluation categorises these methods differently.

At this stage it is important to note that the following discussion of the evaluation procedures involves the evaluation of the first prototype as a "complete system", but still forming part of a bigger design process consisting of more prototypes. Continuous evaluation *did* take place during the design phases of the first prototype. This evaluation generally took the form of a cognitive walkthrough. During such an evaluation session, a physician (an expert in the medical field and familiar with broad computer science principles) would "walk through" a certain part of the system along with the designer. Possible system functionality as well as user interface problems were highlighted. These cognitive walkthroughs were deemed to be of indispensable value to the design process.

Returning to the evaluation procedures of the "complete" (implemented) first prototype, the decision on which evaluation style to use, namely laboratory or field studies, posed a minor problem. Usability laboratories are expensive to set up and this option, therefore, was not at the disposal of the designer.

Considering the "field" in which the prospective user community worked, namely busy general practitioner practices, made it impractical to launch field studies of a prototype system. Trying to convince busy general practitioners to use a prototype - a *first* prototype as such - EPR system as part of their day-to-day tasks, seemed to be a futile exercise.

It was then decided to present the first prototype to general practitioners at a conference by means of a presentation and demonstration and to use questionnaires / evaluation forms (part of query techniques) as a means to perform the evaluation. A brief discussion on the query technique used will now be presented.

- **Query technique**

The first prototype was demonstrated to a group of about one hundred physicians during a course for general practitioners held by the Department of Family Medicine at the University of the Free State on the 16th of May 1998.

A presentation was given where the background of the EPR prototype was explained. The presentation was followed by an on-line demonstration of the system where real-life data was used. The session was concluded with an opportunity for questions from the audience. These questions and the feedback from the practitioners were deemed to be extremely meaningful and heartening.

Each participant was handed an evaluation form at the beginning of the session. They were asked to complete this evaluation form after the conclusion of the demonstration. On a scale from 1 (non-existent) to 5 (excellent), the practitioners had to rate certain aspects relating to the prototype. Ample space was provided for additional comments, critique and recommendations. The processed results of the evaluation forms gave valuable insight regarding the expectations practitioners have of an EPR system. Being confronted with an actual EPR system for the first time, most of the physicians now had the opportunity to visualise the use and impact of such a system. Being confronted with an EPR system in *practice* in comparison to a *theoretical* ideal, made it possible for physicians to come forward with practical advice, problems and recommendations.

- **Heuristic evaluation**

Heuristic evaluation is usually carried out during the design phase of system development. In the scenario of this project, however, it could successfully be carried out on the different prototype systems as well. In comparison to evaluation methods during implementation where the prospective user is actively involved, this type of evaluation is usually performed by the designer.

Dix *et al.* [1998:414] identify a list of ten heuristics to be used to uncover usability problems while critiquing the system:

- Visibility of system status
- Match between system and the real world
- User control and freedom
- Consistency and standards
- Error prevention
- Recognition rather than recall
- Flexibility and efficiency of use
- Aesthetic and minimalist design
- Help users recognise, diagnose and recover from errors
- Help and documentation

These ten heuristics were thus used to evaluate the user interfaces of the two prototypes. Although performed by the designer (with the possibility of subjectivity) the heuristic evaluation turned out to be an extremely fruitful exercise. Being forced to evaluate the system in a structured and methodical way (as suggested by heuristic evaluation), many problems (and positive aspects) were highlighted in the process –

aspects that were previously overlooked. Although this evaluation indicated that the first prototype was on the right track and had some good features, the general impression was left that there was still some work to be done!

Although one cannot argue against the validity and usefulness of performing a heuristic evaluation during system design (as is generally done according to the literature), much can be said to encourage the performance of this type of evaluation on a "complete" system, as was done here regarding the first prototype. Valuable insight can be gained with respect to improvements that need to be brought about when considering a next prototype. Where certain parts of the system are tested against a list of heuristics during the design phase, a much better perspective on the system as a whole can be gained when doing these tests after system completion. This brings the heuristic of consistency to mind. Although consistency should be born in mind throughout the design process, a system can only truly be evaluated for consistency after the system has been completed. Therefore, where heuristic evaluation during system design is seen as a goal to work towards, it is seen as a test for adherence to this goal when performed on a complete system. In the light of the above-mentioned arguments, the author would strongly recommend the performance of heuristic evaluation on complete systems in addition to its application during the design process, especially where prototype design is concerned.

- **Usability testing**

To attempt to measure usability, it was necessary to first determine which usability aspects of an interactive system should be measured. It was decided to use the framework of the usability properties as identified by Dix *et al.* [1993] and adapted by De Wet [1994:76]. These usability principles are summarised in Table 1.1.

For each usability principle a qualitative evaluation was first preformed. It might be argued that these qualitative evaluations are nothing more than a repetition of the heuristic tests already performed. One of the motivational factors for this argument might be that in some cases the qualitative evaluation was done from the designer's point of view (as was the case with the heuristic evaluation), and not from the user's point of view, as is generally the case in usability testing. Although these arguments might have some truth associated with them, the author is of the opinion that the value gained from these qualitative evaluations was of such a nature that they were well worth performing. These evaluations may be viewed as extensions to heuristic evaluation – they were performed in much more detail, covered much more ground and were performed on a relatively low system-level. During these evaluations insight was gained regarding positive as well as negative aspects surrounding the first prototype that would have been totally overlooked had they not been performed. Although many of the comments made during this qualitative evaluation process originated from the designer's perspective, the mere nature of the usability properties forced the designer to regard the system from the user's point of view. The designer so to speak "stepped into the shoes of the user". In many cases the users' input gained through the query techniques and the post-task walkthroughs were, in fact, used as proof of the system's conformance/failure as far as a specific usability principle was concerned. Therefore, in stead of being satisfied with only quantitative evaluation methods (as will be discussed shortly), it was decided to include the qualitative evaluations as a result of their valuable contribution to the evaluation process.

Where possible (and appropriate), quantitative evaluation methods were deployed. In these cases measurement criteria for the usability properties were identified by applying the theory of usability engineering. How were these criteria measured? In order to accommodate all of these criteria, it was decided to compose three tasks that would eventually be given to the subjects (physicians taking part in the evaluation process) to perform. The reason for composing three tasks in stead of one was a practical one. It would have been impossible for the evaluator to, for example measure the duration of the consultation as well as the duration of an error correction exercise simultaneously. Therefore, the criteria were divided among the three tasks in a practical and meaningful way to facilitate the observations that were to be undertaken. These three tasks were presented to the subjects on a task sheet.

Usability Principles affecting Learnability	**The ease with which new users can begin effective interaction and achieve maximum performance**
Predictability	Support for the user to determine the effect of future action based on past interaction history
Synthesizability	Support for the user to assess the effect of past operations on the current state
Familiarity	The extent to which a user's knowledge and experience in other real-world or computer-based domains can be applied when interacting with a new system
Generalizability	Support for the user to extend knowledge of specific interaction within and across applications to other similar situations
Consistency	Likeness in input-output behavior arising from similar situations or similar task objectives
Interaction metaphors	Support for the user to teach new concepts in terms of ones which are already understood
Visual clarity	Eliminating every pixel not serving user-important data, muting minor visual elements, removing distracting patterns, ending clutter, avoiding fussy redundancy in visual signals and continually directing screen design toward a clean, sharp, precise user interface
User guidance and support	The degree to which a system allows users to learn as they use it
Enjoyability	To be used without reluctance, a system must be enjoyable to its users. It is a subjective matter depending on complex and interacting factors
Conceptual (mental) models	The facilitating of the forming of an idea in the user's mind of what a system does and how it does it
Usability Principles affecting Flexibility	**The multiplicity of ways in which the user and system exchange information**
Dialogue initiative	Allowing the user freedom from artificial constraints on the input dialogue imposed by the system
Multi-threading	Ability of the system to support user interaction pertaining to more than one task at a time
Task migratability	The ability to pass control for the execution of a given task so that it becomes either internalised by user or system or shared between them
Substitutivity	Allowing equivalent values of input and output to be arbitrarily substituted for each other
Customizability	Modifiability of the user interface by the user or the system
Control	Providing the user with a sense of being in control of the system at all times, as well as providing choices where possible
Usability Principles affecting Robustness	**The level of support provided to the user in determining successful achievement and assessment of goals**
Observability	Ability of the user to evaluate the internal state of the system from its perceivable representation
Recoverability	Ability of the user to take corrective action once an error has been recognised
Responsiveness	How the user perceives the rate of communication with the system
WYSIWYG	Everything the user sees on the computer screen, tells him what state the system is in – What You See Is What You Get
Task conformance	The degree to which the system services support all of the tasks the user wishes to perform and in the way that the user understands them

Table 1.1 A summary of Usability Properties [Dix 1993, De Wet 1994]

In order to assist the evaluator in performing the "paper and pencil" observations, an evaluation sheet was designed. This evaluation sheet consisted of three pages – one for every task that the user had to perform.

For every task (on every page), the criteria that had to be measured were listed. The evaluation sheet was also expanded to capture data that would be used in the task analysis that still had to be performed.

To explain how the observations were physically performed, the following discussion will be organised under the headings Subjects, Preparation and Evaluation sessions:

Subjects - Referring to the choice of subjects, Dix *et al.* [1998:416] stated that subjects should be chosen to match the expected user population as closely as possible. The testing of actual users would be ideal. If this was not possible, their experience with computers in general, as well as their experience or knowledge of the task domain should be similar.

Ten physicians were recruited as subjects. If they were not general practitioners practicing at the time, they had done so before, or were at the time physicians associated with the Department of Family Medicine at the University of the Orange Free State. The evaluator was satisfied that all of them were experienced physicians capable of bringing their medical expertise to the evaluation session.

A second question that arises when considering subjects for evaluation, is the size of the sample chosen. On this issue Dix *et al.* [1998:416] admit that the size is often determined by pragmatic considerations, for example the availability of subjects. This was a main concern, as general practitioners willing to spend time on evaluating prototype systems amidst their extremely busy schedules, are a scarce commodity. Where a rough sample size of at least ten subjects is recommended [Dix 1998], the eventual sample size of ten was deemed to be sufficient regarding the difficult circumstances of finding subjects.

Preparation - Given the fact that learning is involved in this evaluation method, a "within-groups" design [Dix 1998:424] was used in which each subject performed using both prototypes. In order to avoid transfer of learning (from the first to the second prototype) the subjects were divided into two groups of five each. Each group started the evaluation with a different prototype. Five of the subjects, therefore, were given a set of installation disks for the first prototype EPR system, along with detailed installation instructions and a document containing a detailed example consultation. (The other five were handed the second prototype first at a later stage). Following the steps indicated in the example consultation, the subjects were guided through the prototype and exposed to its functionality. The subjects were given instructions to do the following:

- Install the program
- Work through the detailed consultation example
- Create 2 new families
- Create 2 new patients
- Create 8 different consultations of differing complexity.

They were requested to make an appointment for the evaluation session as soon as they had completed these tasks. These procedures were followed in order to attempt to place all the subjects on equal footing as far as experience with the prototype was concerned (none of them had worked with the prototype before).

Evaluation sessions - The evaluation sessions were conducted on a one-to-one (evaluator and subject) basis. They took place in either the evaluator's or the subject's office, according to the subject's preference.

The subject was handed the above-mentioned task sheet and was requested to perform the three tasks, using the first prototype. The first task was to create a medical note for a specific patient and the second task to add, edit and delete previous illnesses, injuries, operations, etc. for the specific patient. The third task was to create a medical note, but before finalising the note, the subject had to correct a mistake made earlier in creating the specific note. Before commencing, the whole process as well as the tasks to be performed, were explained with care. It was stressed that it was the system, and not the subject, which was the "object under scrutiny".

As the subject started performing the tasks one by one, the evaluator was ready with the previously mentioned evaluation sheet, a pencil and a stopwatch (paper and pencil observational technique). The

different aspects, as can be seen in the evaluation sheet in Appendix H, were noted. To compensate for the limitation of the evaluator's writing speed, especially where the steps that the subjects followed had to be noted, a coding scheme was determined beforehand. Examples include:

T= Typing	P= Problem occurred	B=Button
Cb=Select from combo box	Cl=Click	Sb=Status bar message
DbCl = Double-click	TAB=Press the TAB key	

After the session, post-task walkthroughs (refer to section 6.2.3.2) were held where possible problems were discussed with the subject to clarify the observations. Useful remarks were often made by subjects regarding their experiences with the prototype. Each evaluation session lasted for approximately thirty minutes. As mentioned before the same evaluation procedures were followed for the second prototype as well.

Results

USABILITY PRINCIPLES	PROPOSED QUALITATIVE CRITERIA
Learnability	
Predictability	Do similar buttons (e.g. OK, Cancel) always yield the same results? Can the same actions be applied to similar components?
Synthesizability	Does the system indicate that a change occurred (e.g. successful save) by displaying appropriate messages?
Familiarity	Is the user interface familiar in terms of the user's task experience?
Generalizability	Could the user apply his/her knowledge of Windows to simplify the use of the new system?
Consistency	Is/Are the colour-use/screen layout/actions/components consistent throughout the system?
Interaction metaphors	Was it possible to relate the computer tasks to tasks in the real world?
Visual clarity	Did you perceive the screens as clear, well-organised, unambiguous and easy to read?
User guidance and support	Does an on-line help facility exist? Are hints incorporated in the system? Are the labels descriptive?
Enjoyability	Did you enjoy using the system?
Conceptual (mental) models	Was it simple enough to form an accurate idea of what the system does and how it does it?
Flexibility	
Dialogue initiative	Did you have freedom of movement throughout the system?
Multi-threading	Could you perform more than one task at a time?
Task migratability	Did the system allow you to interfere during the performance of certain tasks?
Substitutivity	Could you use information displayed by the system as input to a following command?
Customizability	Was it possible to add your own choices to the lists displayed in combo boxes/list boxes?
Control	Did you feel in control of the system while using it?
Robustness	
Observability	Was it possible to browse through information of importance? Were defaults provided everywhere where it was needed? Was it easy/possible to reach all the options that you wanted to use? Did the system communicate effectively/provide adequate information?
Recoverability	Could you understand the error messages? Did the error messages recommend solutions to rectify the problem? Was it easy to return to the previous state after an error was made?
Responsiveness	Was the system's reaction to your commands fast enough?
WYSIWYG	Did your printed copies resemble the screens?
Task conformance	Was it easy/possible to perform your tasks on the system?

Table 1.2 Recommended criteria for qualitative evaluations

The evaluation methods used to evaluate the two prototypes may be applied to similar projects in future. To put the valuable (and tested!) experience gained during the evaluation process to use, the following will be presented as guidelines for the evaluation of prototype-developed systems:

- Start the evaluation process by applying query techniques, for example the distribution of questionnaires, to the largest possible group of the potential user community. This will serve as a valuable starting point in assuring that, broadly seen, the project is on the right track (or the contrary!). This will also introduce the user community to the project and will prepare the way for establishing contacts with potential participants in future evaluation procedures.
- In addition to performing heuristic evaluations at specified intervals (pre-defined milestones) during the design process, much can be gained from performing heuristic evaluations on the completed system (or the completed prototype, if applicable). This will ensure that the user interface goals that were set during the design-phase heuristic evaluation, are in fact adhered to in the final system.
- When performing usability testing, both qualitative and quantitative measures should be applied. Both of these measures may be obtained from comparing the system under evaluation to the usability properties listed in Table 1.1.
- Qualitative evaluation may be performed by constructing criteria for each of the usability properties. These criteria may be presented to the users in the form of informal questions asked during, for example post-task walkthroughs. A recommended list of the qualitative criteria is presented in Table 1.2.
- The quantitative evaluation may be performed on the basis of the criteria listed in Table 1.3. It is important to note that the association of criteria with the usability properties (in both Tables 1.2 and 1.3) is the author's own initiative. There might still be room for expansion of the lists, but they present a valuable point of departure.
- The conducting of a task analysis to test a system's task conformance (the association of a task analysis with task conformance also being the author's own initiative) forms an indispensable part of the evaluation process. It allows the designer to perceive the system at a much lower level than all the other methods. Most importantly, however, it places the designer "in the shoes of the user", viewing the system from the user's perspective. The interface is torn apart, so to speak, only to be put back together again, piece by piece, with amazing insight along the way!
- When gathering data for the purpose of the usability testing and subsequent task analysis, paper and pencil observational techniques may be carried out quite successfully, with the following pre-conditions:

    - The observational sessions should be planned thoroughly beforehand.
    - Care should be taken that no disruptions (phone calls, visitors, etc.) take place during the observations.
    - When recruiting the subjects to participate in the evaluations, they should be fully informed about the project, the purpose of the evaluation, what the evaluation sessions would entail, how long it would approximately take and their contribution and involvement in the project.
    - Before commencing with the observations, the tasks should be carefully explained to the subject. He/she must be re-assured that the system, and not he/she, is under scrutiny.
    - The sessions should not be too lengthy.
    - If one evaluator makes the observations, the specific criteria to be tested should be spread over a few tasks. This would enable the evaluator to keep up with the different aspects to measure, and will allow for more time-related criteria to be tested (one person handling more than one stopwatch at a time is bound to create chaos!).
    - Care should be taken in the design of the evaluation sheet (on which the measurements are transferred by the evaluator during the observations). It should facilitate ease of reading and use. The use of standard abbreviations on this sheet to compensate for slow writing-speed is highly recommended.
    - From experience, it would be suggested that at least two evaluators attend the observation sessions. This would serve as a counter-act for human error and more accurate results may be produced.

USABILITY PRINCIPLES	PROPOSED QUANTITATIVE CRITERIA
Learnability	
Predictability	Number of times that the user asked for assistance Number of times that the user expressed frustration
Synthesizability	Number of times that a message appeared in the status bar
Familiarity	Number of times that the user asked for assistance
Generalizability	Number of times where ENTER was pressed in stead of TAB
Consistency	N/A
Interaction metaphors	N/A
Visual clarity	N/A
User guidance and support	Number of times that the user asked for assistance
Enjoyability	N/A
Conceptual (mental) models	N/A
Flexibility	
Dialogue initiative	Number of times that the user was prohibited from following a step/path
Multi-threading	Number of times where keyboard-use was attempted in vain
Task migratability	Number of times where the system asked for confirmation
Substitutivity	Number of times output on tables were used as input
Customizability	Number of times where the user would have preferred different options /values
Control	N/A
Robustness	
Observability	Number of static default values on the screen Number of dynamic default values on the screen Number of times that a message appears in the status bar
Recoverability	Time duration to make a correction Number of steps necessary to make a correction
Responsiveness	N/A
WYSIWYG	N/A
Task conformance	Time duration to create a consultation

Table 1.3 Recommended criteria for quantitative evaluations

Conclusions

The evaluation methods described in this article were used with great success. It is therefore believed that the guidelines for the evaluation of prototype-developed systems (as presented here) could, therefore, be of great value and assistance to evaluators of similar projects in future.

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A Recommended Model for EPR Systems to be used by General Practitioners in South Africa

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Abstract

In a joint venture undertaken by the Departments of Computer Science and Informatics and Family Medicine at the University of the Free State in Bloemfontein, South Africa, a model for an EPR system to be used by general practitioners in South Africa, was presented. This model was based on the specific needs and requirements as identified by South African general practitioners. In the process of developing this model, two EPR prototype systems were designed, developed and evaluated in turn. The feedback of general practitioners themselves was continuously sought for during this process. The results of the evaluation methods that were applied to the two prototypes, as well as lessons learned from other EPR ventures in the rest of the world, resulted in the recommended EPR model. The model could therefore be implemented and presented to South African general practitioners as an EPR system brought about with the contributions and input of general practitioners themselves.

Introduction

Electronic patient record (EPR) systems are not generally used in South Africa (SA). This is the case despite the numerous problems that physicians experience with their current manual record systems. In a joint research project undertaken by the Departments of Computer Science and Informatics and Family Medicine at the University of the Free State in Bloemfontein, SA, an attempt was made to identify the needs and requirements of general practitioners (GPs) in order to present them with an EPR system suited to their specific requirements.

Initially a questionnaire was sent to a selected sample of general practitioners. The results of this questionnaire left a clear impression that GPs in SA believed in the concept of the EPR, that they definitely felt a need for it and that they would use it (personally), when available.

A first EPR prototype system was developed. An extensive evaluation process was performed which included a presentation to one hundred general practitioners (query techniques), a heuristic evaluation and usability testing (qualitative and quantitative). A task analysis also formed part of the latter. The results of the evaluation of the first prototype system were incorporated into the design of the second prototype. The second prototype was then also evaluated (in a more hands-on manner) in conjunction with a third alternative, the HUB medical Computer System (based on the Foresighted Practice Guidelines principle) following the same basic evaluation principles as was used to evaluate the first prototype. From these evaluation results a recommended EPR model for general practitioners in SA was presented. This model will now be described.

Recommended EPR model

In summarizing the most important features of the recommended EPR model, two main aspects will be highlighted, namely its user interface and functionality.

- ***EPR model user interface***

The EPR model should be a Windows application. It should have a graphical-based user interface where direct manipulation and form filling interaction styles are combined. The keyboard and mouse should both be used to accomplish human-computer interaction.

The main departure point for the model's user interface should be simplicity, or more precisely, functional simplicity. The prospective user community of the EPR is South African general practitioners. Therefore the computer skills of the prospective users vary from none to expert. These users should be able to use the EPR as a tool in conducting patient consultations. The *functional simplicity* mentioned earlier would therefore require an understandable, easy-to-learn, easy-to-use, but functional user interface. The user interface should, in effect, disappear in order to allow the physician to concentrate on the task at hand.

Using the tab-method as basis could contribute largely towards a successful user interface. This would allow for freedom of movement within the EPR - the user would not be forced to follow certain pre-defined paths. The user is thus presented with a feel of control - a major contributor to successful human-computer interaction. The tab-method would also contribute towards the requirement of a "short consultation", where the consultation should be created in as few steps as possible.

Throughout the EPR model, the user should be presented with options where choices among different values are applicable. The use of combo box and grid components in the user interface would make this possible. In a further attempt to facilitate ease of use, ample provision for default values on the EPR screens should be made. The most popular choices are displayed in edit fields or combo boxes, permitting modification of these values if so required. The selective use of specialized screen components, for example calendars, could greatly enhance the user interface. In stead of typing the date (with possible resultant typing errors), the user is presented with a visual calendar where the date may be selected using the mouse to click the appropriate day.

The recommended main colour for application in the EPR model is the popular Windows gray. This could be supplemented with teal (specifically as a grid colour). In cases where it is deemed essential to attract the user's attention immediately, red could be used (for example to display the patient's allergies). The above-mentioned colour scheme was positively received by the users and was considered to be "soft on the eyes". This is important when considering the circumstances in which an EPR will be used - in busy general practices with physicians with more than their fair amount of daily tasks to perform, as users!

- ***EPR model functionality***

A prospective user should gain access to the EPR model via user identification and a password. In cases where more than one physician works in a specific practice, a list of physicians may be presented on the first screen. When selecting the appropriate physician, the corresponding password, therefore, needs to be entered.

In order to comply with the way patient records are currently kept, the EPR model should follow the notion that every patient belongs to a family. The family information pertains to the person responsible for the account. A family, therefore, needs to be selected/created before a specific patient can be addressed. A family may be searched for by entering search criteria. In the case of the EPR model, searches may be conducted on family account numbers or by entering the complete/part of the family surname. The search

feature may be extended to allow for searching on a first name, address, birth date or medical aid. When located, demographic information regarding the family should be displayed. A list of patients "belonging" to the family should follow. By selecting the appropriate patient, demographic information pertaining to the specific patient should be displayed. An important addition to the patient screen may be the patient's allergies listed in red (where applicable).

Another important aspect regarding the recommended EPR is a list of past consultations that might be displayed on the patient screen. These consultations should be listed according to the dates and times of occurrence. By selecting a consultation date, the information captured during the specific consultation (the medical note) is displayed on the screen. The user should also have the option to print the note. Consideration should be given to the WYSIWYG usability principle here to ensure that the printed version resembles the version on the screen.

The capturing of the clinical note should be done according to the internationally accepted SOAP model. The four screens containing the information required by the SOAP model will now briefly be discussed in turn.

History(S) screen - The History screen should contain two different types of information. The first type is basic information pertaining to the current consultation, namely the consultation date and time, the attending physician, the nature of the consultation, whether it is a first or follow-up consultation and the main complaint of the patient. The second type of information on the screen involves the patient's medical history. This includes screens for entering/modifying/deleting previous illnesses, operations, injuries, investigations, medications and allergies. The family history and general profile, as well as systemic history of the patient may also be entered.

Examination(O) screen - The basic patient parameters (including the body mass index and indicators regarding this index and the abdominal circumference, e.g. "obesity"), the vital signs, general appearance, systemic examinations and side room investigations should be captured on this screen.

Assessment(A) screen - The problem list should be created on the assessment screen. Problems, problem dates, outcomes and outcome dates are added or modified. Extensive viewing facilities could also be provided for. The user could be given the choice of viewing the whole problem list, problems between two date ranges, all the active problems, or all the active problems between two date ranges. The differential/final diagnosis may also be entered on this screen.

Plan(P) - The Plan screen should allow for entering Dx, Rx and Cx information. When selecting a new Dx investigation, provision should be made to view the results of previously entered investigations. To assist in entering Rx information, the patient's allergies (where applicable) should again be listed. Provision should also be made for indicating a follow-up consultation date by presenting the user with a visual calendar.

The user should be allowed to move among these four screens as desired until a confirmation button is pressed. Once the consultation is confirmed (a confirmation message is displayed to allow the user to change his/her mind), no changes may be made in order to comply with medico-legal terms. To accommodate for human error, a Modify facility should be provided for. This should allow the user to attach notes to existing consultations by selecting the specific date and time of the previous consultation.

It often happens that a physician is interrupted by a phone call during a specific consultation. If this interruption is in respect of a query regarding another patient, the recommended Query facility in the EPR model will allow him/her to cope with the situation. The physician may leave the current consultation screen, move to the Query screen, retrieve the patient record in question, answer the query (by looking at a previous consultation) and subsequently return to the consultation screen where he/she left off.

The recommended Maintain option provides for limited customization. Lists presented to the user on various screens are maintained here. Options may be added, modified, or removed. The lists that should (at

least) be provided for in the EPR model are titles, languages, marital status, medical funds, relationships, systems, consultations, Dx and investigations.

It is important to note that the user should be allowed to exit the system at any time during the consultation. An exit-button should constantly be visible at the bottom-right of the screen. In an attempt to avoid the accidental pressing of buttons, a confirmation message should be displayed to confirm the user's intention of leaving the system.

As a result of the extensive evaluation that was performed on the two prototypes, it is essential that the following issues should be emphasized and subsequently incorporated into the EPR model.

- Using the second prototype took up too much time. The major reason for this time aspect was the amount of typing needed to create an electronic consultation. Computer illiteracy/inability to type contributed substantially to this state of affairs. By presenting the user with choices to choose from, in stead of expecting them to type in information, the use of the recommended EPR model can be sped up. The user, however, does not want to drown in all the possible choices, or feel lost halfway during the use of the system use. The suggested solution to finding this middle course is to allow the user to fully customize his/her choices. This implies that the user may, for example enter his/her own choices that should appear in the drop-down combo boxes. To accommodate the users who would prefer the extra freedom of typing information, memo fields can be provided on request. In this way the fast point-and-select principle can be incorporated into the EPR model.

  The above-mentioned possible solution is one suggestion to help solve the time problem associated with the second prototype. What other options exist? Another way to address the problem, as was suggested by one of the evaluators, is by providing the user with a "long" and a "short" consultation. A "long" consultation implies that all the information, as is currently combined in the EPR model, is presented to the user. The "short" consultation, in contrast, will only consist of a *minimal data set*. This would imply that only absolutely essential information would be captured on this screen. The option of a "short" consultation could be presented to the physician as a totally separate system, or as an extra screen within the existing system. The author would suggest the latter, *if* this time-reduction option were to be pursued. As the evaluators of the second prototype indicated that they were, in principle, satisfied with the screen layout, organisation and content thereof (with the indicated additions, of course), it is suggested that these aspects should be kept intact and therefore incorporated into the model. A separate screen with only essential information on it could then be added. This would, however, imply that consensus should be reached among physicians as to what *essential information* entails.

  Another (simpler) option to consider (in contrast to providing a separate screen) is to provide easy access to the consultation confirmation button, as was also suggested by one of the evaluators. The easiest way to comply with this suggestion is to place this button at the bottom of the screen, on the left-hand side of the "Exit"-button. The "Confirm this Consultation"-button will then be visible and accessible from all the screens in the system. It will, therefore also facilitate a "short" consultation as the user can enter the main complaint and press the button without having to leave the current screen. The rest of the system will remain intact.

- Despite being "fast-using", what other features should this EPR model have? It should include a printing facility for the medical note, the reminder and prescriptions. In addition to the patient's full first names, provision should be made for the name with which the patient would wish to be addressed. The church denomination should also be transferred from the family to the patient screen. A report facility where ad-hoc queries for research purposes can be compiled, should also be included in the EPR model. Error messages should not only identify errors, but should include purposed solutions to the errors. An on-line help facility should form part of an EPR system and undo/redo actions should be possible. In order to comply with Windows standards, a cut/copy/paste facility should also be provided for.

- Although the following aspect has already briefly been touched upon before, it is important to provide for multiple levels of access to ensure security. One of the essential requirements in this regard is to allow the physician to determine the level of access that his/her receptionist may have. It is generally accepted that the receptionist will enter the demographic information of families and patients. Some physicians would, for example require the receptionist to additionally enter the results of specialist reports, or the patient's medical history into the system. The system should, therefore, provide for these different levels of access. As an additional feature, the receptionist could also be allowed to schedule patients, as was done in the HUB Computer Medical System.

- As far as the issuing of prescriptions is concerned, a decision of principle was made. The existing medical financial/administration packages, almost without exception, already cater for prescriptions. Re-inventing the wheel is not viable. Therefore a decision was made to provide for *limited* prescription functions to accommodate those physicians who do not have access to another facility. In the Rx information block a physician can compile a prescription that can be printed afterwards. The EPR model, as was previously discussed in this section, already provides for this function. What needs to be done additionally, is to provide the physician with customized options regarding the prescriptions. If dispensing is done in the consulting rooms, he/she should be able to draw up a list of medications (and associated information) that is available in their medicine cabinet. This would allow him/her to fill out a prescription by clicking on the available options of his/her choice.

In the next section an explanation will be given as to how the recommended EPR model would interact with the Health Care environment.

The EPR in the Health Care Environment

An EPR system on its own would not be viable in practice. Most physicians who use computers in their practices have some sort of financial/administrative medical computer system already in place. Building these financial/administrative functions into an EPR system would also be like re-inventing the wheel. Why do it when there are so many financial/administrative systems available on the market already? It should, therefore, be possible for an EPR system to link up to existing financial (or other, like stock control) packages. There are presently two formal medical interfacing protocols, namely High Level-7 (HL-7) and Medical Optical Reader Form (MORF). HL-7 is used for order/entry to laboratory systems and MORF is used for converting information from medical notes to medical billing, order/entry, lab systems, inventory and pharmacy systems [Naegele 1995]. Therefore provision for linkage via HL-7 and/or MORF should be made.

The matter of links highlights the issue of linking with code structures (a requirement mentioned in the evaluation process). Recent changes in legislation and in Health Care in SA have brought about new requirements that physicians need to adhere to with regard to medical aid companies. The requirements were necessary, among other reasons, to combat a growing tendency of fraud in medical aid claims. To fully understand all these coding requirements, physicians would need to attend a full-time course of a few days. The additional manual administration that was brought about with these changes requires additional resources in a medical practice. All these aspects will make it almost impossible for a physician to cope in future without a computer in a medical practice. This also brings about the need for a computer system to be able to handle these coding structures and the links to codes. The EPR program is the logical place where the linking should take place, as this is where diagnosis and procedures are determined.

From the results of the questionnaires and the evaluation results of the first and second prototypes, communication links between the general practitioner and other role players in Health Care, for example pathologists, medical funds, radiologists, etc., have been ear-marked as of the utmost importance. As an example, a request for a specific pathological investigation should automatically be sent electronically to the specific pathologist as soon as the patient's consultation has been confirmed on the EPR system. The results of this investigation should then be returned to the physician, also electronically, and automatically linked to the patient's medical record. This procedure would imply easy access to an e-mail facility where the EPR program would handle the compiling of the message. A pre-requisite for this facility is that the

other role players would also be geared towards this electronic contact. Many of these institutions, however, already make use of the electronic media, and it would only be a matter of time before the rest would follow suit. Consideration can be given to electronic communication with the patient. This could be useful for electronically sending, for example reminders to patients. The e-mail facility should therefore be added to the existing EPR system in order to contribute to our ideal EPR model.

The electronic contact with Health Care role players involves two special requirements. The first requirement involves the handling of X-ray images. The possible scenario here would be the following: the physician requests a specific x-ray investigation for a patient. As soon as the consultation is confirmed, a message is compiled and sent to the appropriate radiologist via e-mail. When the patient arrives at the radiologist, the request already awaits him/her. The consequent x-ray is then scanned at the premises of the radiologist and electronically sent to the requesting physician. Here it will be linked to the appropriate patient record. The physician will be warned that this image awaits his/her attention. The requirement for the proposed EPR model is to provide viewing and storing of this x-ray image (the e-mail aspect has already been mentioned above).

The second special requirement that electronic contact with role players brings to mind is that of specialist reports. Although the final prototype caters for these reports in that a summarised version may be entered into the system, quite a few physicians indicated during the evaluation that they would like to have a scanning facility. It goes without saying that they would need the scanning equipment in the first place. The EPR model would then have to provide for the viewing and storing of these scanned reports. This will be available as an additional option to the already mentioned one, as it is believed that, especially initially, only a few physicians will have access to scanning equipment.

Conclusion

Why would general practitioners use an EPR system based on this presented model? Does the system stand any chance at all? The answers to these questions may be found in the following facts:

- In the research conducted on the status of the EPR in the rest of the world, lessons were learnt from the mistakes made in other countries that ventured on the path of creating an EPR system. This second-hand, but valuable experience was incorporated when the EPR model was designed.

- General practitioners themselves were involved in the design of the model. The research pertaining to the model was done from the ground level upwards - the South African general practitioners' requirements, needs and preferences are reflected in the model. Their requirements were the building blocks of the model. It was not a case of a computer scientist view being forced on an EPR system. General practitioners were also heavily involved in the evaluation and testing of the prototypes on which the model was based. They are co-owners of the model, so to speak. It is a South African model for South African circumstances - a first of its kind.

- Finally, the approaches being promoted by the present major players within the Health Care industry are simply not working. EPR systems are not acquired or used at present. This leaves a large opening for a small medical software developer to come up with an idea that will do it better and cheaper, with the requirements of physicians as main goal. This might put well-established firms in jeopardy, while giving a system along the lines of the EPR model the edge.

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Abstract

Information drives the practice of medicine. Unfortunately physicians drown in the amount of information engulfing their day-to-day tasks. The invention of the patient record was the first step in trying to bring order to this situation. Numerous problems are, however, experienced worldwide with the manual paper patient records that have been in use in medical practices for the past few years. The obvious answer to overcome these problems is an electronic patient record (EPR).

In South Africa (SA) the EPR is not generally used, despite its well-known potential advantages. Focussing on general practice, a research project therefore was undertaken to:

- Ascertain whether a need for EPR systems exists
- Identify problems associated with current paper medical records
- Identify the requirements, expectations, and needs regarding EPR systems
- Design and present prototype EPR systems for evaluation and testing by general practitioners (GPs) in SA according to their requirements, expectations, and needs as mentioned above
- Present the GPs of SA with a model of a proposed EPR system, specifically designed for their requirements, expectations, and needs.

The results of questionnaires that were sent out indicated that the GPs in SA realised the need for implementing computers in their practices. As in many parts of the world, they do experience frustrating problems with their current manual systems. These include mis-filed and lost files, difficulty in recording external work, the identification of old, unused files, the durability and transferability of files, duplication, illegible/incomprehensible files that become too thick too fast, and the physical storage space for these files. The computer systems currently used in general practice focus mainly on administrative and

financial duties, and there is a need to integrate these functions with clinical EPR's. The GPs also gave an indication of the type of system they would consider implementing.

Despite some problems that were foreseen, a clear impression was left that GPs believed in the concept of the EPR, that they definitely felt a need for it and that they would use it (personally), when available.

Two prototype EPR systems were developed. The first prototype was demonstrated to a group of GPs to get a general idea of the system's compliance with their requirements. It was further put to the test by applying heuristic and usability evaluation methods. The latter was done in conjunction with the paper and pencil observation technique. The results of these evaluation methods were analysed and applied in the development of the second prototype.

After the completion of the second prototype EPR system, a third alternative, namely the HUB Medical Computer System (based on the Foresighted Practice Guidelines principle) was acquired. It was deemed important to test this as an alternative to the template principle on which the first two prototypes were based. The second prototype and HUB were evaluated in a hands-on laboratory evaluation. Similar evaluations techniques to those applied to the first prototype were performed on the second prototype as well. Additionally the first and second prototypes were compared to each other with the aid of a task analysis.

The users identified positive aspects in the HUB system. The second prototype was, however, received with enthusiasm. By taking the evaluation results to heart and using the second prototype as basis, an EPR model was thus presented. Broadly viewed, this model involves a graphical user interface (accessed via mouse/keyboard) based on the Tab-method, entering of consultations via the SOAP model, a query, report and printing facility, customization, and communication with the health care environment via e-mail

and medical protocols. In future EPR systems for GPs in SA could be based on this model.

Key terms

Electronic patient record; EPR; Computerized patient record; CPR; Paper medical record; PMR; EPR model; Computer-based patient record; General practice.

Opsomming

Inligting is die dryfveer vir mediese praktykvoering. Ongelukkig verdrink geneeshere in die hoeveelheid inligting wat hulle dag-vir-dag take verswelg. Die uitvinding van die pasiëntrekord was die eerste stap in die poging om die situasie te probeer orden. Verskeie probleme word egter wêreldwyd met die papier (hand) pasiëntrekordstelsels, wat vir die afgelope paar jaar in gebruik is in mediese praktyke, ondervind. Die logiese oplossing om dié probleme te probeer oorkom, is 'n elektroniese pasiëntrekord (EPR).

Ten spyte van sy alombekende voordele, word die EPR nog nie algemeen in Suid-Afrika (SA) gebruik nie. Met die oog op die algemene praktyk, is 'n navorsingsprojek dus onderneem om:

- Te bepaal of 'n behoefte aan 'n EPR bestaan
- Probleme wat met huidige papier mediese rekords bestaan, te identifiseer
- Die vereistes, verwagtings en behoeftes rakende die EPR the identifiseer
- EPR prototipe-stelsels te ontwerp en aan algemene praktisyns (AP's) in SA voor te lê vir evaluasie en toetsing na aanleiding van hulle vereistes, verwagtings en behoeftes
- 'n Model van 'n voorgestelde EPR stelsel, spesifiek ontwerp vir hulle vereistes, verwagtings en behoeftes, aan AP's in SA voor te lê.

Die resultate van vraelyste wat uitgestuur is dui aan dat AP's in SA die behoefte aan die implementering van rekenaars in hulle praktyke besef. Net soos in verskeie dele van die wêreld ondervind hulle frustrerende probleme met hulle huidige handstelsels. Dit sluit in foutief-geliasseerde en verlore lêers, probleme in die vaslegging van eksterne werk, die identifikasie van ou, ongebruikte lêers, die duursaamheid en oordraagbaarheid van lêers, duplikasie, onleesbare/onverstaanbare lêers wat te vinnig te dik word en die tekort aan fisiese stoorspasie vir die lêers. Die rekenaaarstelsels wat tans in algemene praktyk

gebruik word fokus meestal op administratiewe en finansiële take en daar is 'n behoefte aan die integrasie van hierdie funksies met die kliniese EPR. Die AP's het ook aangedui watter tipe stelsel hulle vir implementering sal oorweeg.

Ten spyte van probleme wat voorsien word, is 'n duidelike indruk gelaat dat die AP's in die EPR-konsep glo, dat hulle beslis 'n behoefte daaraan het en dat hulle dit (persoonlik) sal gebruik, indien beskikbaar.

Twee prototipe EPR stelsels is ontwikkel. Die eerste prototipe is aan 'n groep AP's gedemonstreer om 'n algehele gevoel te kry van die stelsel se voldoening aan hulle vereistes. Dit is verder getoets deur heuristiese- en bruikbaarheids-evaluasiemetodes toe te pas. Laasgenoemde is uitgevoer aan die hand van die papier-en-pen observasietegniek. Die resultate van hierdie evaluasiemetodes is ontleed en toegepas in die ontwikkeling van die tweede prototipe.

Na voltooiing van die tweede EPR prototipe is 'n derde alternatief, naamlik die "HUB Medical Computer System" (gebaseer op die sogenaamde "Foresighted Practice Guidelines" beginsel), aangeskaf. Die toets hiervan as alternatief tot die templaat beginsel waarop die eerste twee prototipes geskoei is, is as belangrik beskou. Die tweede prototipe en die HUB is in 'n "hands-on" laboratorium-situasie ge-evalueer. Soortgelyke evaluasietegnieke as dié wat op die eerste prototipe uitgevoer is, is ook op die tweede prototipe uitgevoer. Die eerste en tweede prototipes is addisioneel met mekaar vergelyk aan die hand van 'n taakanalise.

Die gebruikers het positiewe aspekte in die HUB geïdentifiseer. Die tweede prototipe is egter met entoesiasme ontvang. Deur die evaluasieresultate ter harte te neem en die tweede prototipe as basis te gebruik, is 'n EPR model voorgestel. Basies behels die model 'n grafiese gebruikerkoppelvlak (met toegang via die muis/sleutelbord), gebaseer op die *Tab*-metode, die invoer van konsultasies via die SOAP model, 'n navraag-, verslag- en drukfasiliteit, gebruikeraanpassings en kommunikasie met die gesondheidsorgomgewing

via e-pos en mediese protokolle. In die toekoms kan EPR stelsels vir AP's in SA op hierdie model gebaseer word.