Development and Usability Heuristic Evaluation of an Application in PDA for Supporting Physicians Tasks at the Point of Care

by

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Abstract

The main goal of this project was to develop a PDA based application to support physicians' documentation tasks at the point of care in hospitals. Nowadays, software for portable devices, such as the PDA, is commonly used among physicians in hospitals. This is indicative that physicians are probably accustomed to this type of technology and that it will not be an obstacle for them to use a PDA based clinical documentation application to perform their tasks related to patient care. The application developed supports most of the physician's documentation tasks such as viewing the patient's record, performing medical orders, and entering progress notes. This makes the application a very useful and an important tool for the physicians in the hospitals in Puerto Rico.

Resumen

El principal objetivo de este proyecto fue desarrollar una aplicación basada en PDA para soporte de tareas de documentación por médicos en el punto de cuidado en los hospitales. Hoy en día software para dispositivos portátiles, tales como el PDA, son comúnmente utilizados por médicos en los hospitales. Este es un indicativo de que médicos están acostumbrados probablemente a este tipo de tecnología y que esto no será un obstáculo para que utilicen una aplicación de documentación clínica basada en PDA para realizar sus tareas relacionadas al cuidado del paciente. La aplicación desarrollada soporta muchas de las tareas de documentación de médicos tales como visualización de registro del paciente, realización de órdenes médicas y entrada de notas de progreso. Esto hace a la aplicación una herramienta muy útil e importante para los médicos en los hospitales en Puerto Rico.

To my husband Edward Javier Herrera for your unconditional love

To my parents Ramiro Olarte Chacón and Elizabeth Enciso Tejada who gave me the life and are the inspiration of what I want to be nowadays; my sisters Laura and Roxana and my small nephews Mariely and José Ramiro, who bring me light with their smiles.

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List of Abbreviations

CW	Cognitive Walkthrough
ER	Expert Review
EW	Expert Walkthrough
G	Guidelines
GPRS	General Packet Radio Services
GSM	Global System for Mobile Communications
GW	Guidelines Walkthrough
HCI	Human Computer Interaction
HE	Heuristic Evaluation
HW	Heuristic Walkthrough
ISO	International Organization for Standardization
JAMA	Journal of the American Medical Association
PDA	Personal Digital Assistant
UEMs	Usability Evaluation Methods
UMTS	Mobile Telephony Standard
WIMP	Windows, Icons, Menus and Pointing device

CHAPTER 1, INTRODUCTION

1.1. Justification

Wireless systems, like Personal Digital Assistants (PDAs), have been one of the fastest growing development areas in the past few years. The sales of PDAs had increased dramatically and the range of potential application environments for these portable wireless devices is almost limitless. One of those application fields in which PDAs have drawn a lot of attention is the health care industry. Their portability and ability to link to a central database without a hard-wired connection may offer tremendous benefits in helping health care personnel access, manage, and share medical information and allows for near-unlimited potential in developing point-of-care applications.

In spite of the advances in technology and the proliferation of information systems, the health care industry in Puerto Rico and the USA is still lagging in the successful implementation of such technology. This is especially true with regard to information systems to support clinician's documentation and point-of-care activities. Although many physicians use PDAs to assist them in their work, some haven't an application that is integrated to all the systems at the hospital or health's center where they work. Many hospitals in Puerto Rico have computer systems for tasks such as patient registration, health care plan management, medication orders, laboratory orders, and billing. However, most of these applications and the information managed are not integrated. As a result, most hospitals in Puerto Rico still manage much of their information in paper, especially the clinical information related to patient care.

As health care grows more complex, the access to timely information, and the ability to communicate effectively about patient care are more important than ever. Paper-based clinical records have many disadvantages such as: duplication of information, lack of clarity or difficulty to read, limited access and management of the information, and most importantly, the potential of errors. Due to these limitations and other documented problems of paper-based patient records [Rodriguez07] and with the fundamental goal of improving the attention of patients at the point care, our project aims to develop a PDA based application to support the physician's documentation process.

1.2. Objectives

The main objective of this project was to develop a PDA based integrated application to support the physicians' tasks at the point of care in hospitals that allow physicians to improve the quality of care. Several physicians' documentation tasks have been considered by this application such as: medical orders, consultations orders, management of problems list, use of protocols, and progress notes. Another objective was to incorporate usability principles into the development (early stages of analysis, design and interfaces implementation) of the application. Also, conduct a usability heuristic evaluation to assess the results. The application of usability engineering principles in the development of user interfaces is fundamental [Borges07] since it is the most important factor that determines the acceptance and use of the application by the users

The application for physician's documentation should record the patient's clinical information and satisfy the necessities of the physicians and patients. It should be complete

enough to allow substituting the use of paper as the mean of storing and managing the information. The use of mobile device technology should allow portability, accuracy, security, ease of use and integration of patient information. This will result in better quality service at the point of care.

1.3. Outline

Previous work related to the use of PDA's in health care applications are described in Chapter 2. In addition, this chapter describes usability studies carried out on PDA applications and comparative studies with other devices such as Laptops and Tablet PCs. Chapter 3 describes in detail the PDA application and interfaces developed for physician's documentation. A description of the usability aspects in the development process and in the interfaces of the system is discussed in Chapter 4. The heuristic usability evaluations conducted on the system and the results of the evaluation are described in Chapter 5. This chapter also includes the impressions about the system from evaluators once the evaluation was completed. Finally, Chapter 6 includes the conclusions from this project and recommendations for future work.

CHAPTER 2, PREVIOUS WORK

2.1. Introduction

For many years physicians have been using Desktop PC's health applications to manage or handle their daily activities. In recent years, the use of Personal Digital Assistants (PDAs) has been growing, even more than the use of Desktops PCs in the health area, specifically among physicians. This is due to the portability PDAs with wireless technology, and to the benefits such as rapid access to patient information, automated data transfer to and from medical instruments, messaging, notification, telemetry and tracking within Hospital wards [Metzger03].

A study conducted in the United States [Metzger03] reports that approximately 98,000 individuals die each year due to medical errors. Of those, 25% have been originated by the bad calligraphy of the physicians. According to the study, this originates a cost to society of $15,000 millions per year. This statistic has been very influential in the growth of medical applications for devices like PDAs that can reduce and eliminate medical errors in hospitals and health centers of the United States and other countries in the world

The need for usability studies in medical informatics has increased due to the amount of medical applications available for purchase. Studies of applications to support medical activities at the point of care have been conducted on systems based on PDA, Laptops, Tablets, Desktop PCs, and paper forms.

A study described by Yao [Yao00], indicates that many of the applications have difficulties in aspects such as: poor organization of available resources; ignorance of the availability of relevant resources; lack of time to search for information; lack of up-to-date resources; non-availability of resources and unrecognized information needs. Shortening the time required to search for relevant information and making results easier to obtain are very important aspects to consider at the moment of developing a medical record application. Therefore a usability study is very important and an essential component of the development process.

Applications in PDA allow effective management of the medical practice, but to achieve this, it is very important to consider the usability issues. This chapter describes some research and usablility studies related to the use of devices like PDAs in health care applications.

2.2. Use of PDAs in Health Care Applications

The terms PDA, handheld computer, Palm and Pocket PC all refer to similar devices with similar capabilities and technology. The Personal Digital Assistants (PDAs) were introduced in 1995 by the company 3Com®. Since then, PDAs began a new stage of slow but progressive growth. Today, a wide range of applications have been developed for different areas like: engineering, merchandise, banking, finances, economy, laws, and medicine.

A wide range of mobile devices are also used by health care professionals to improve the efficiency and effectiveness for delivering patient care. Most of these PDA based health

applications allow access to the information by means of wireless technology in a quick way and in a few steps using pen-based computing, in many cases without the necessity of typing data. Likewise their portability, thanks to their small size, serves as main instrument in the daily work of health professionals.

On the other hand, it is also important to mention some of the disadvantages of the PDAs in comparison to the Desktop PC and Tablet PC. The smaller size of the screen on PDAs limits the amount of visible information at one time. Due to the absence of a keyboard, entering information in a PDA is harder. In addition, the battery life of these devices varies from 2.5 to 4 hours, which prevents a continuous use of these devices for a full workday [Han07].

2.3. Health Care Systems

In the last years, several researches and projects have taken advantage of PDA technology in health care systems to improve the quality of care and reduce its cost. The University of Technology at Sydney, Australia proposed a client architecture with an integrated workflow agent to manage outpatient workflow in a mobile hand held computing system [Uppu06]. This project, developed in the Advanced Research Networking Laboratory, provides rapid access to patient's information through agent monitors in a mobile healthcare management system which alerts the health professionals with the required information regarding the condition of the patient.

A European project called Ward-In-Hand [Pappas02] developed a system to assign tasks to healthcare professional like physicians and nurses. This system serves like a single

ward where physicians and nurses are equipped with a mobile device connected to a ward server through a wireless network. The system collects all the clinical information and communicates with the hospital's legacy system.

ProMED [Uppu06], a project sponsored by Apple computer and the US Department of Defense for military medical practice, provides an application on the Newton Message Pad with a graphical user interface (GUI) and wireless communication. This system replaces the paper based process and allows the physician to intervene with the patient in a natural way. Using the system would require a shorter time to obtain information from the patient so the healthcare professionals would be able to offer better services at the point of care.

A group in the Brigham Young University developed the Pocket Doktor system [Uppu06]. This system uses wireless communication to obtain patient medical information through a personal device. The system consists of a smart card that stores data, and reads and displays patient information to medical professionals when treatment is required. However, the system does not support interfacing and synchronization with existing records.

Other mobile health systems have been introduced as telemedicine applications [Voskarides01] which includes wireless technologies to span the areas of emergency health care, telecardiology, teleradiology, telepathology, telemathology, teleophtalmology, teleoncology, and telepsychiatry. With the use of mobile devices, this system allows granting services at understaffed areas like rural health centers, ambulance vehicles, ships, trains, airplanes, and patient home monitoring through modern wireless telecommunication like Global System for Mobile Communications (GSM), General Packet Radio Services (GPRS), Mobile Telephony Standard (UMTS), and satellite communications. Another

interesting telemedicine application is Ambulance and Emergency-112 [Voskarides01]. This application is based on two projects that allow emergency telemedicine services between ambulance vehicles and distanced expert physicians. By mean of portable devices and via wireless communication, this project has the objective of allowing expert physicians to assess the severity of emergencies by means of a bidirectional GSM voice communication an to allow instructing the paramedics how to handle the case.

Another system, called MOTOHEALTH, was developed based on Motorola's platform [Lacal05]. The system leverages Mobile Computing and Communication Devices MCCD as part of Mobile Tele-Health mTH solutions which helps to alleviate some of the demographic and financial burdens imposed on the healthcare systems today. Basically mTH is centered on the notion of the patient's body as the point of care.

2.4. Usability Studies of Health Care Systems

Currently, many hospitals want to improve the attention of patients at the point of care. This would allow the physicians and nurses to be more efficient in the attention of their patients as compared with traditional hospital information systems. Such information systems must consider the usability aspects of the design.

Usability is of utmost importance because the primary concern of physicians and nurses is the patient and not the information system [Carlsson06]. On the other hand, medical systems based on recent technology have resulted in many orders with wrong medications because either they avoid considering usability aspects in their designs or because the result of the usability evaluations of the design has not been understood.

According to a research published by “The Journal of the American Medical Association” (JAMA) [Nielsen05] about the role of computerized physician order entry systems, there are twenty-two ways in which the system caused patients to get the wrong medicine. For example: system screens that listed dosage based on the medication units available through the hospital’s pharmacy; physicians that changed the dosage of a patient’s medication and entered the new dose without canceling the old one; or when the patient name appeared in a small font that was difficult to read. As described by Nielsen, the main reason for these issues was usability problems in their systems. Some of these issues were: misleading default values, new commands not checked against previous ones, poor readability, memory overload, date description errors, and overly complicated workflow. For this reason hospital computerized physician order entry systems was considered as a technical solution to medication ordering errors.

The importance of including usability considerations and conducting usability evaluations on health applications is vital. This will help reduce errors significantly in the process of patient care and other aspects such as the ease in learning the application, satisfaction of the physician and patient, and effectiveness and efficiency of the application.

A research group at the University of Puerto Rico in Mayaguez has developed several applications for physician’s and nurse’s clinical data documentation. The main objective of this group is to conduct usability studies to determine the impact on the acceptance, learnability, efficiency, and satisfaction of physicians and nurses.

One of these projects compared the physician’s interaction with two different systems [Rodríguez04]. It evaluated and compared the performance of physician’s task using text-

based and graphical-based electronic patient record systems. The results showed that physicians had more satisfaction interacting with a graphical-based electronic patient record system than with the text-based system.

Another related research project [Rodríguez03] compared two versions of a nursing documentation application. One version used a PDA and the other a Laptop. The result of the study showed that the tasks of looking for the most recent vital signs, acknowledging a pending medication order, entering I/O measurements, and entering a daily assessment took less time on a PDA than on a Laptop. On the other hand, the tasks of reading a paragraph, entering a set of vital sign measurement, and writing a note took significantly less time on a Laptop than on a PDA.

A comparative study of nurses accessing electronic patient record systems with a PDA and a Tablet PC [Crespo05] was also conducted. The results of the study showed that there were no significant differences in the time that took nurses to complete typical tasks on a PDA and on a Tablet PC. It demonstrated that the nurses were as fast on a PDA as on a Tablet PC. The results also indicated that there were no significant differences in nurses' satisfaction with both versions.

A study by SAP Research CEC Darmstadt in Germany was conducted to show how wearable computing can be utilized to achieve a usable solution at the point of care [Carlsson06]. To achieve this mock-up design a usability study of a medical system was developed to observe the interaction among physician, nurses, and patients at the point of care. The mock-up was constructed using Macromedia Flash and was installed on a Tablet

PC and PDA for the physician and nurse respectively. The usability test showed that the mock-up prototype can help physicians and nurses at the point of care.

Another usability test was developed by the Norwegian University of Science and Technology in Norway [Ole06]. Prototype systems for the attention to patient in a clinical environment were implemented. The prototypes were developed and tested to show the interaction using PDA together with bedside PCs between physician and hospitalized patients at the same time. The objective was to develop a comparative usability evaluation of experimental systems in PDA and bedside PCs (patient terminal) of seven different interaction techniques as: WIMP on PC, drag and drop, screen extension, PDA as input device, remote control, WIMP on PDA, proximity and mirroring and using both devices [Ole06]. According to the results, the technique Windows, Icons, Menus and Pointing device (WIMP) on PDA is the most preferred for users (physician and patient) since the users found this interaction technique easier and faster to use. With this technique, when the physician makes a selection on the PDA, the object that it refers to is showed on the patient's terminal. The factors affecting the usability were: the usability of the graphical user interfaces, ergonomics and screen sizes, preference concerning presenting information on a shared display, and focus shifts and time away from the patient.

A usability evaluation of a mobile medical information system was conducted in Albo Akademo University in Finland. The purpose was to determine if a mobile medical system developed primarily for the civilian medicine could be expanded to be used in military medicine [Han07]. This study included an evaluation of the mobile medical system on a mobile device-Nokia 9210 Communicator. The result concluded that both the mobile system

and the device-Nokia 9210 have a degree of readiness for military medicine. In addition, the study showed that it is very important that the civilian and military medicine have mobile systems with a friendly and easy to use device to increase the quality of health care at the point of care.

The previous works described in this chapter are some among the innumerable research existing in the branch of the health care electronic systems and usability. Most of these researches were conducted to study issues regarding: portability of systems, accessing and sharing health information, increasing the quality of care, reducing the risk and errors, and providing health care at the point of care. This demonstrates the value of usability in electronic health care systems because it can make these critical services and products easier to learn, understand, and use.

CHAPTER 3, DESCRIPTION OF THE APPLICATION

3.1. Introduction

This chapter provides a description of the interfaces of the PDA application for physician's documentation at the point care. The application was developed in C Sharp using Visual Studio .Net 2005 from Microsoft. This application used MS SQL Server 2000 as database agent. It stores and retrieves information related to the physician module as well as the nursing documentation module developed in another project. Thus, the database is consistent and integrated for the physician and nurse documentation.

The "Centro Cardiovascular de Puerto Rico y el Caribe" and "Advanced Cardiology Center - Mayagüez" were chosen to conduct the task analysis and to gather the information regarding the physicians' documentation process. This information was analyzed, and evaluated according to the tasks carried out by the physicians during the intervention with their patients.

The application developed in this project is focused in the physician's intervention with patients at the point of care. The first interaction of the physician with the system is to select the patient that will be attended at the moment. Once a patient is chosen, the main menu of the system provides access to all the interfaces of the system. These interfaces are: Summary, Diagnosis, Order, Protocol, Problem List, Notes, and Consult. Through these interfaces physicians can access patient information and document their intervention with

the patient. Due to the small screen size of PDA, most of these interfaces are composed of several sub-interfaces. A special emphasis was placed on the Physician's Order interface, since it is the most common task of the physicians during their intervention with patients. This interface is composed of six sub-interfaces, shown in six tabs, allowing access to specific types of orders.

The following sections of this chapter provide a general description of all the interfaces of the application. The descriptions also include the characteristics and advantages of each user interface developed for the application.

3.2. Login Interface

The first interface of the system is the Login interface. This allows entrance to the system by specifying the user name and password of the user (Figure 3.1), in this case the physician. The system allows entrance into the physician's module after it validates the identity of the user. This validation guarantees access to the system to authorized personal only.

Figure 3.1 Login Interface

3.3. Patient List Interface

Once a physician enters into the system, a Patient List interface is displayed (Figure 3.2). This list shows only patients under the care of the physician that signed into the system. The interface displays a list with the names and rooms of the patients. In addition, for some patients, an icon is displayed on the right side of the patient's name indicating that there is a consultation request from another physician for that particular patient.

The user can view additional information regarding a consultation request by selecting the patient with a Consultation icon. This action shows the physician's name and the date of the consultation request in the bottom of the interface beside the Open button, as it

is shown inside the red oval in Figure 3.3. In order to view the complete details of a consultation request the user must press the Open button.

From the Patient List interface, the user can either enter the Physician's Consultation interface or the Summary interface. For both options, the user must select a patient from the list and then press the Open button. If the patient has a Consultation icon on the right side, the Physician's Consultation interface will be displayed; otherwise the Summary interface will be displayed. Both interfaces will be shown further on.

Figure 3.2 Patient List Interface

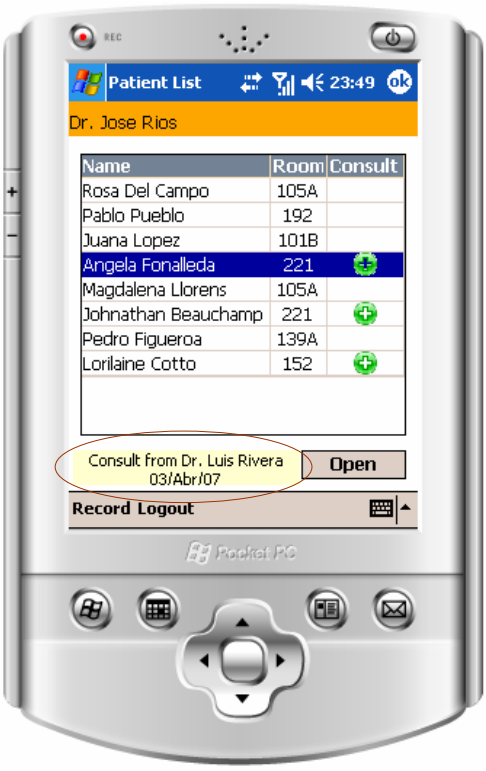

Figure 3.3 Patient List Interface with Consultation Request

3.4. Physician's Consultation Interface

Once the physician selects a patient from the list who has a consultation request the Physician's Consultation interface is displayed (Figure 3.4a). At the header of the windows this interface displays relevant information of the chosen patient, such as, name, age, weight, and room number. This header will be present on all the interfaces of any patient. In addition, the Consultation interface shows the relevant information regarding the consultation such as the physician's specialty, the reason of the consult, the maximum time to respond, and the details of the consultation. On the left side of the interface there is a Menu of options (Figure 3.4b) that allows the user to enter into the Summary interface or to enter into the Progress Notes interface. Both interfaces will be described further on.

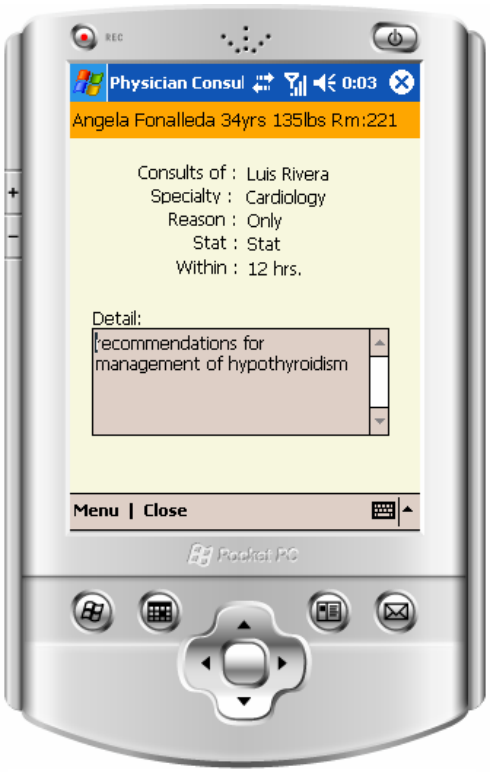

Figure 3.4a Physician's Consultation Interface

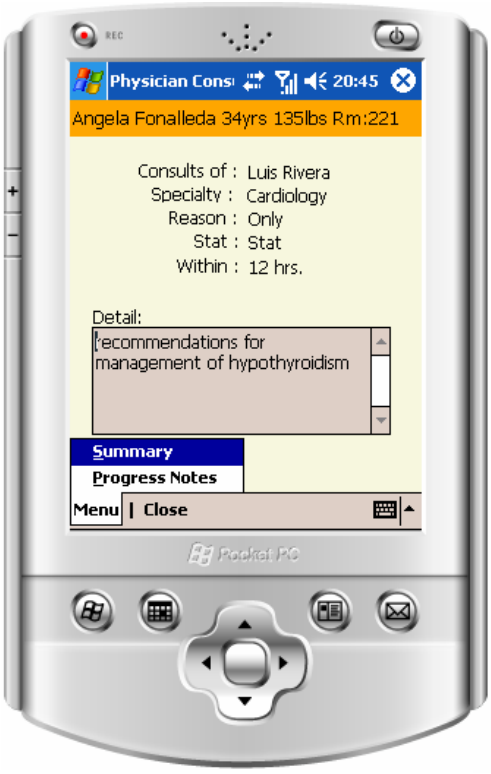

Figure 3.4b Physician's Consultation Interface with Menu of options

3.5. Summary Interface

Once the physician selects a patient form the list (who doesn't has a consultation request), the Summary interface is displayed. This interface displays a summary of the patient most relevant information to the physicians. It includes the problem list, the medications administered, the laboratories and studies carried out (Figure 3.5a), and the last four vital signs taken (Figure 3.5b). With this information, the physician will be able to see a panorama of the patient's current situation.

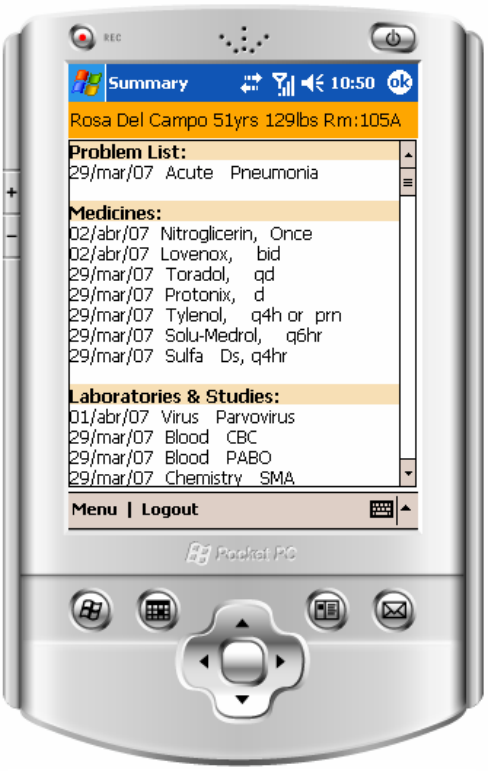

Figure 3.5a Up Summary Interface

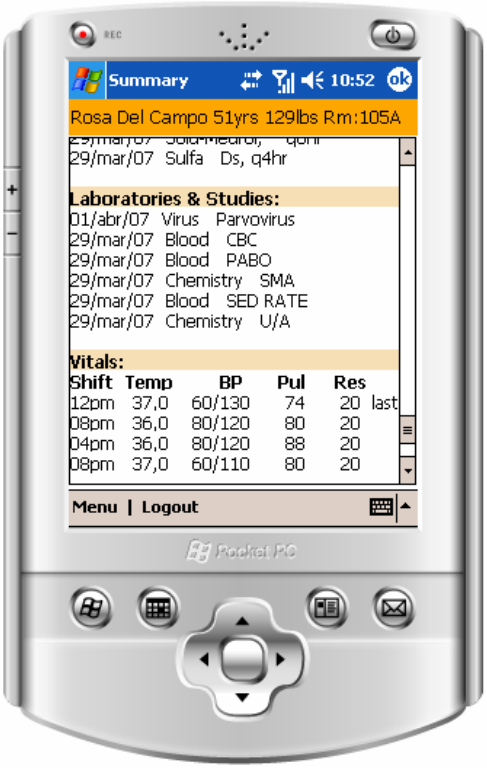

Figure 3.5b Down Summary Interface

On the left bottom corner of the Summary interface there is a Menu option that provides access to the system options (Figure 3.6) available for the physician's documentation. The menu includes the following options: diagnosis, order, protocol, problem list, notes, record, and consult. Some of these the interfaces will be detailed further on.

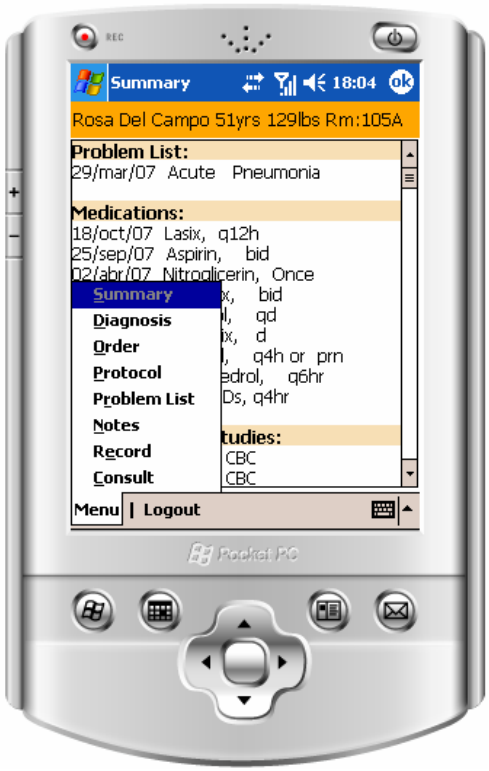

Figure 3.6 Summary Interface with Menu of options

3.6. Diagnosis Interface

This interface allows the physician to view and/or register the patient's diagnoses. The first interface shows all the diagnoses previously entered for the particular patient. These diagnoses are displayed in a list that shows the diagnosis label and date of registration when the physician entered the diagnosis to the patient (Figure 3.7).

To enter a new diagnosis the physician must press the New Diagnosis button which will open the New Diagnosis interfaces (Figure 3.8). In this interface the physician can add one or more diagnosis to the patient. For this, the user must select a diagnosis from the combo box and add it to the list below of the interface. This combo box obtains the diagnosis options from the database. In cases in which the information desired is not in the database, the system allows the physician to enter and save new diagnosis that will be validated further on. In addition, this interface also has a Delete, Add and Return button. The Delete button allows the user to remove one or more diagnosis added to the list of the patient's diagnosis entered at the moment by the physician. The Add button allows the user to save the diagnosis entered at the moment into the data base. Finally, pushing the Return button will return to the interface of diagnosis entered previously for the particular patient (Figure 3.7). To close this interface, the physician must press the Close button which will return them to the Summary interface.

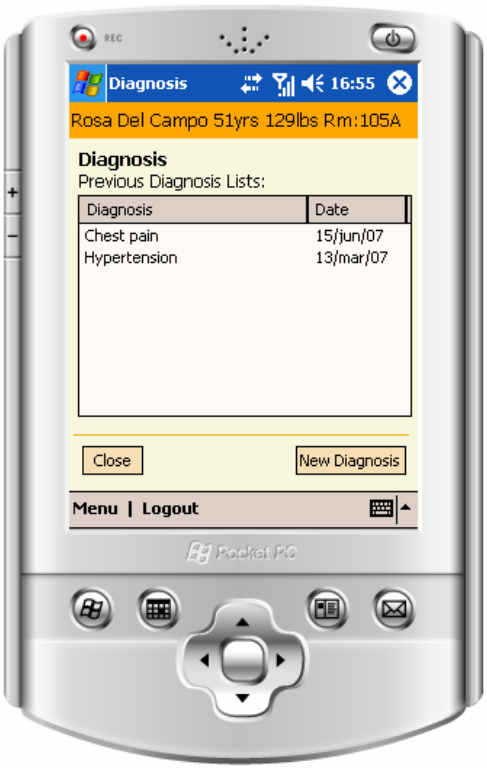

Figure 3.7 Diagnosis Interface

Figure 3.8 New Diagnosis Interface

3.7. Physician's Order Interface

The Physician's Order interface allows the physician to carry out one of their main tasks during their intervention with the patient at the point of care, to submit an order. The Physician's Order interface is composed of many sub-modules based on specific types of orders. These includes: medication, laboratory, study, consultation, and others. Each one of these is represented and accessed by six different tabs. All the types of orders included in the Physician's Order interface have an Add button for appending the orders to a Visualized Tree of Orders. The physician will be able to see the information added by selecting the icon representing the Visual Tree of Orders that is located at the right bottom corner of the

interface, beside of the tabs of orders. Once the physicians have verified all the orders, they will be able to submit it to the database and save this information in the patient's record.

3.7.1. Medication Order Interface

The Medication Order interface is accessed with the first tab in the interface (Figure 3.9). This displays different text/combo menu boxes to allow physician's to select information from menus and thus facilitate the entrance of data into the order. These combo boxes obtain the menu information from the database. In cases in which the information desired is not in the database, the system allows users to enter and save new information. Information entered this way must be validated later. For example, when ordering a medication, if the one desired is not present in the combo box (not in the database), the user can insert a new medicine and then this medicine be part of the order (added subject to validation to the database).

In this module the physician can specify medication, dose, frequency, route, stat, starting date and end date in which the medication should be given. In addition, users have the option to write additional text making click on the Details button which opens a window allowing text input (Figure 3.10). Finally, physicians have the option of selecting the Eprocrates icon to enter into the Eprocractes system [Crespo04] for cases in which additional information about medications is desired.

This interface allows users to order one or more medications by making a click on the Add button. This information will be added to a Visualized Tree of Orders, which will be shown further on.

Figure 3.9 Medication Order Interface

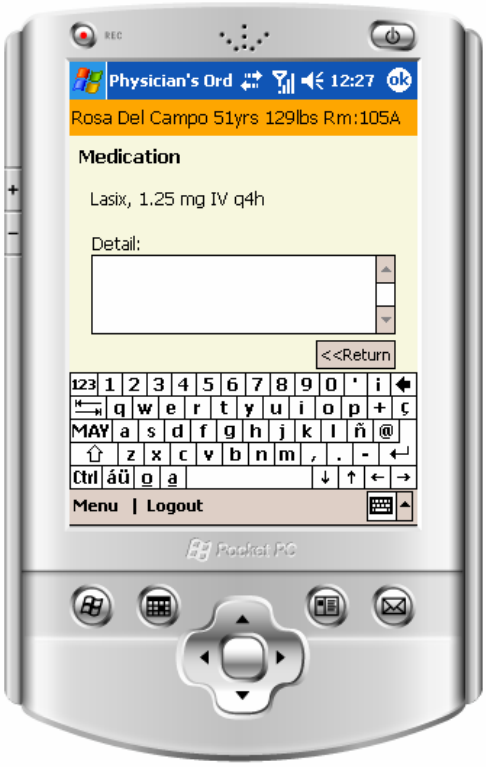

Figure 3.10 Medication Detail Order Interface

3.7.2. Laboratory Order and Study Order Interfaces

The second and third tab of the order interface provides access to the Laboratory Order and Study Order interfaces respectively (Figure 3.11 and Figure 3.12). Both interfaces are very similar. These interfaces display radio buttons of the laboratories and studies that are most common in order to facilitate the specification of an order. If the laboratory and study are not in the radio buttons, the users must choose from combo boxes according to a type of the laboratory and study respectively. In addition, the user can specify the frequency of the order, the times, and write any additional text making click on the Details button. The details option works in the same way as in the medication order (Figure 3.10).

Just as was shown in the medication order, the physician can order more than one laboratory test and study by press a click on the Add button to add to the Orders Visualization Tree.

Figure 3.11 Laboratory Order Interface

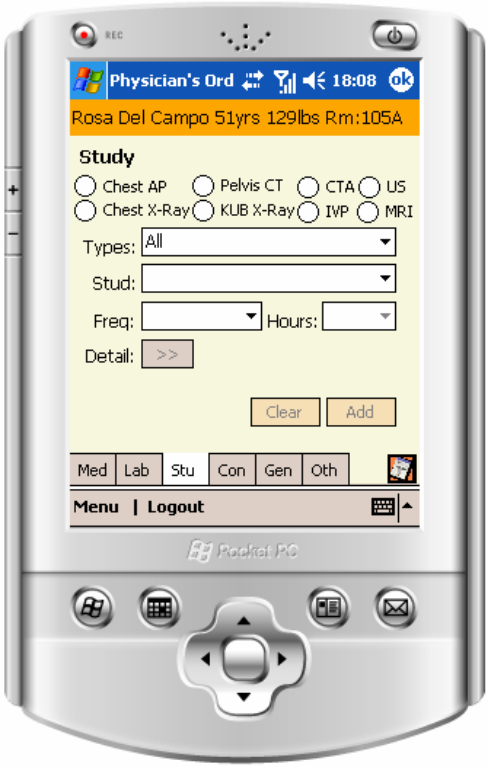

Figure 3.12 Study Order Interface

3.7.3. Consult Order Interface

The fourth tab of the Physician's Order interface is the Consult Order interface (Figure 3.13). This interface allows users to request a consultation from another physician. Through the text boxes users can select physicians according to a specialty area inside the hospital or health center. The specialty and physicians are displayed in the combo boxes according to the information of the database. In addition, this interface has radio buttons to

specify the reason of the consultation. The options are: consult only, follow up, and free to order. The user can also write additional information in regard to the consultation request by selecting the Detail button. Similar to other types of orders, the user can order several consultation orders and add them to the Visualization Tree.

Figure 3.13 Physician Consult Order Interface

3.7.4. Generals Orders Interface

The fifth tab of the Physician's Order interface is the General Orders interface which provides access to the Vital Signs Order interface and the Diet Order interface. Users can move or navigate between these two interfaces by clicking on the arrows or by selecting from the combo box at the bottom part of the page.

The Vitals Sign Order interface (Figure 3.14) has four radio buttons that allows physicians to order vital sign readings every two, three, or four hours. By default the interface has checked the radio button with four hours since this is the most common order in hospitals. The text box allows physician's to specify a different frequency if desired.

The Diet Order interface (Figure 3.15) consists of check boxes representing the most commons diets. The physician can order a diet by selecting a check box or by selecting the type of diet from the combo box and then selecting a diet in particular. The system also has a Details buttons to insert in a text box any additional detail to the diet ordered and a Delete button to eliminate the diet that have been discontinued.

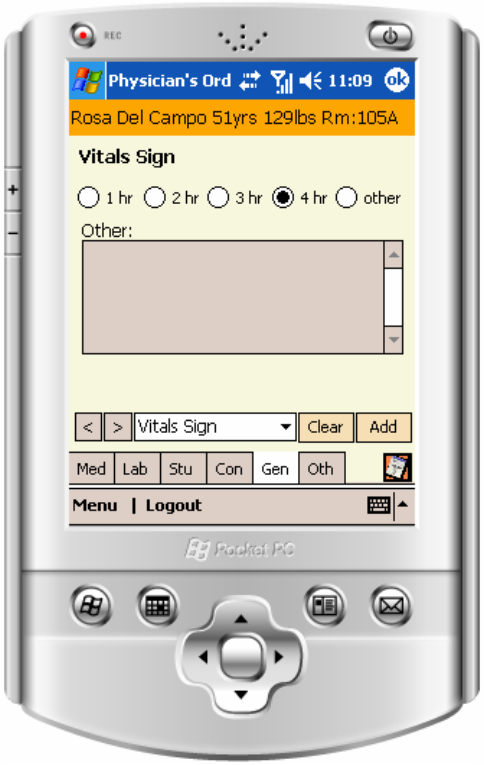

Figure 3.14 Vital Sign Order Interface

Figure 3.15 Diet Order Interface

3.7.5. Others Orders Interface

The sixth tab of the Physician's Order interface is the Other Orders interface (Figure 3.16, Figure 3.17, Figure 3.18, and Figure 3.19). Within this tab users can select from the following eight interfaces: Input/Output, Personal Hygiene, Ambulatory, Care of Tube Drainage, Physical Therapy, Respiratory Therapy, Restraint and Blank Order. Most of these interfaces are similar to each other with the exception of Input/Output, Restraint, and Blank Order interface. The navigation among the different interfaces can be done by means of the arrows or the combo box at the bottom part of the interface.

The Personal Hygiene Order interface (Figure 3.16) provides different radio buttons to specify an order and a text box to specify other orders not included in the radio buttons. The Ambulatory, Care of Tube Drainage, Physical Therapy and Respiratory Therapy interfaces are similar to the Personal Hygiene interface.

The Input/Output Order interface (Figure 3.17) consists of one check box to order input/output readings. The Restraint Order interface (Figure 3.18) consists of two pages, each one of them with check boxes to order different restraint conditions for the patient. To access these pages, two buttons with the numbers 1 and 2 are showed in the bottom of Restraint Order interface. These buttons allows the user to navigate between both pages. When a button is selected it changes color to indicate the active page.

Finally, the Blank Order interface (Figure 3.19) allows the physician to enter any other type of order that is not included in the system. The physician must enter a title and a detail for the Blank Order interface through the two texts boxes displayed.

Each interface of Others Orders interface is shown in Appendix A.

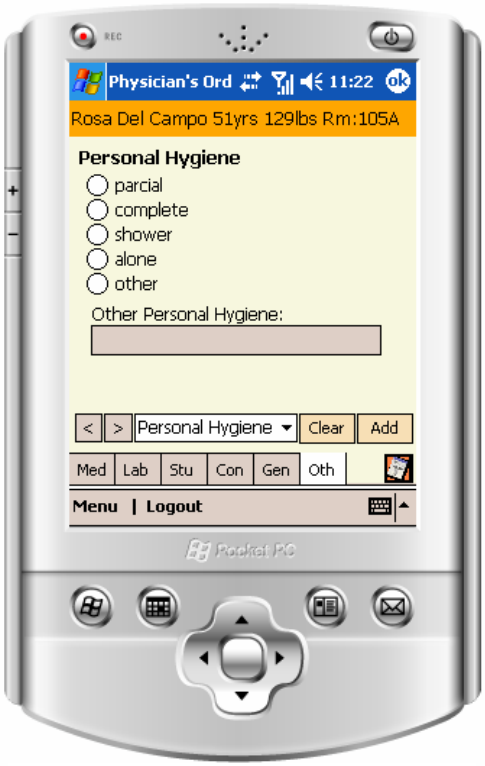

Figure 3.16 Personal Hygiene Order Interface

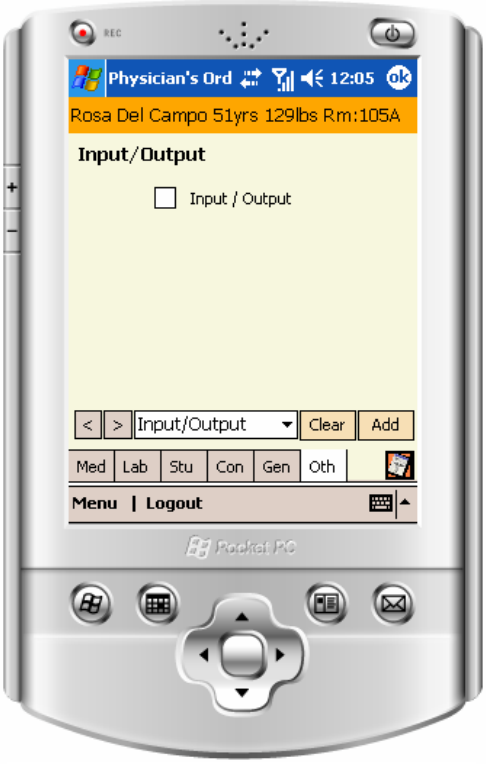

Figure 3.17 Input/Output Order Interface

Figure 3.18 Restraint Order Interface

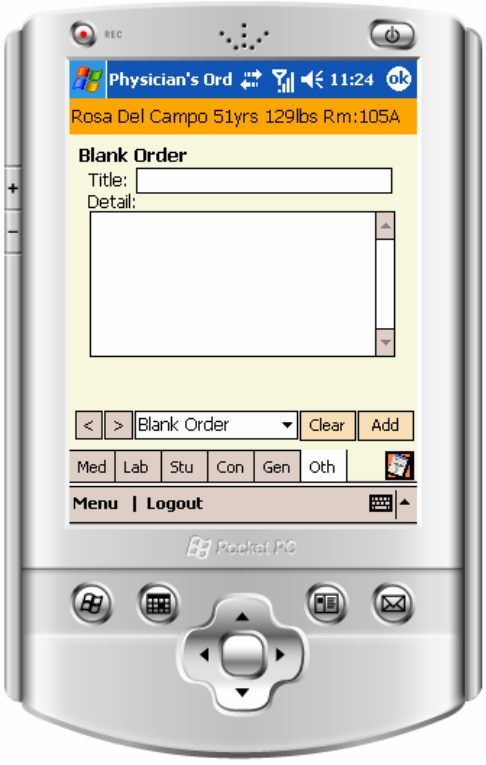

Figure 3.19 Blank Order Interface

3.7.6. Explorer Interface or Visualization Tree of Orders

This interface displays all the orders specified by the physician using a Visualization Tree (Figure 3.20). The main nodes of the tree are the medication, laboratory test, studies, consult, general, and other. Each node contains a complete description of the orders specified by the physician within the corresponding category. From this interface, the user can also edit or delete any order in particular. To edit an order the user can double click on a specific order description or select the order and press the Edit button. The system will then open the corresponding interface of the order selected and allows the user to edit it. To delete an order the user must select the order form the tree and press the Delete button. After asking confirmation from the user, the system will eliminate this order from the Tree of Orders. Finally, once a physician is satisfied with all the orders shown in the tree, he can submit the entire order by means of the Order button. This will store the entire order in the database.

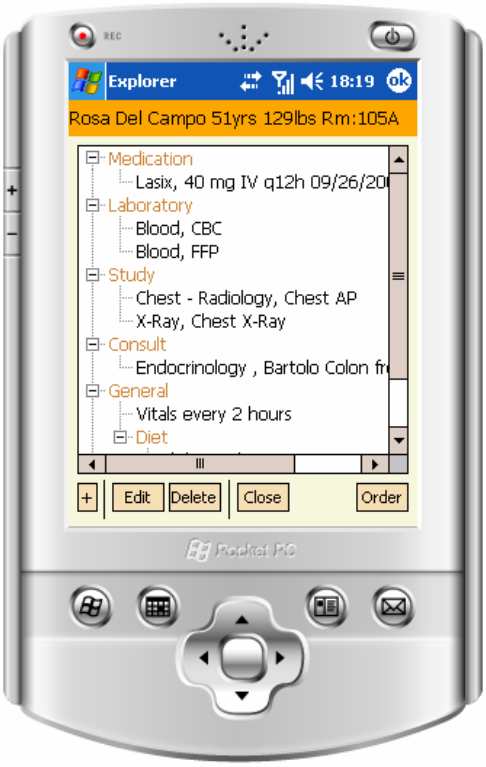

Figure 3.20 Orders Explorer Interface

3.8. Protocol's Order Interface

The protocol's order can vary depending on the hospitals. According to the information gathered from "Centro Cardiovascular de Puerto Rico y el Caribe" hospital, the physicians carry out different protocols for specific medical orders. These protocol's orders can be designed or adjusted to any other hospital but certain differences exist.

The Protocol Order interface allows the physician to view a list of protocols that are managed by the hospital such as: Acute Myocardial Infarction and Congestive Heart Failure (Figure 3.21). To access the interface of any of these protocols, the physician must choose the name of the protocol. Once the protocol is chosen, the user must press the Select button (In this case Acute Myocardial Infarction Protocol interface).

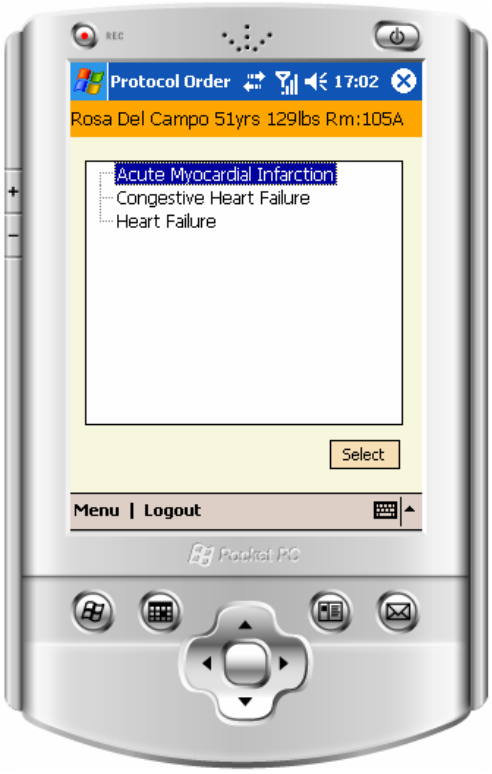

Figure 3.21 Protocol Order Interface

The Acute Myocardial Infarction Protocol interface is composed of six different pages (Figure 3.22a, Figure 3.22b, Figure 3.22c, and Figure 3.22d). To access any of the pages the user must press the squares with numbers that are in the bottom of the interface. The color of the number of these squares will become orange once this page is accessed.

Each page of the protocol is composed of radio buttons, text boxes, and check boxes, which allow the physician to make the orders of acute myocardial infarction protocol. In case the user selects a radio buttons or check boxes, the corresponding text boxes (if any) will be activated. Furthermore, the input panel of the system will be displayed when a text box is activated allowing the user to enter information in the protocol's order (Figure 3.22c).

At the bottom of the windows, each interface of protocol has a Clear Pag button on the right side. This button clears all the inserted information on the page.

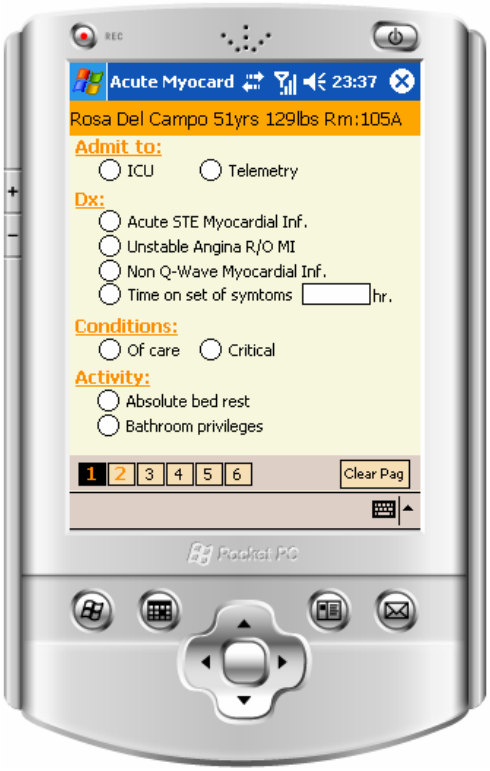

Figure 3.22a Acute Myocardial Infarction Interface (Page 1)

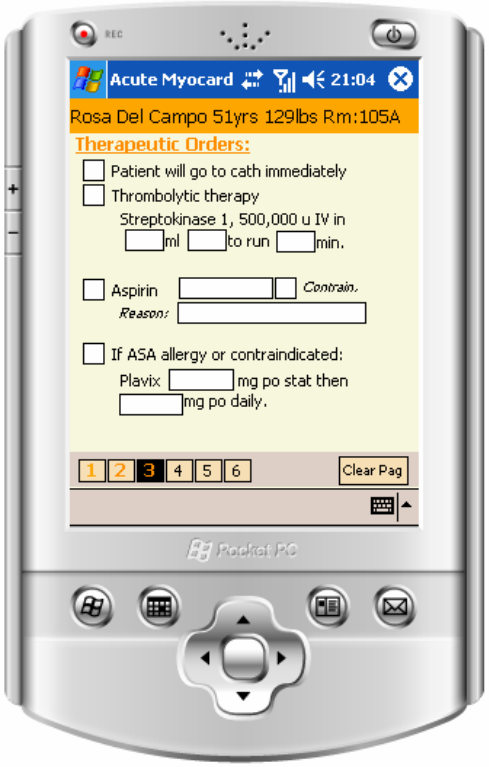

Figure 3.22b Acute Myocardial Infarction Interface (Page 3)

Finally, when the user is in the sixth page, the Close and Preview button is displayed (Figure 3.22d). The physician must press Preview button to see a report of the inserted data in all the pages of the protocol. To cancel all the changes made in the protocol's order and close this interface, the physician must press the Close button to return to the Summary interface.

Each page of Acute Myocardial Infarction Protocol interface is shown in the Appendix B.

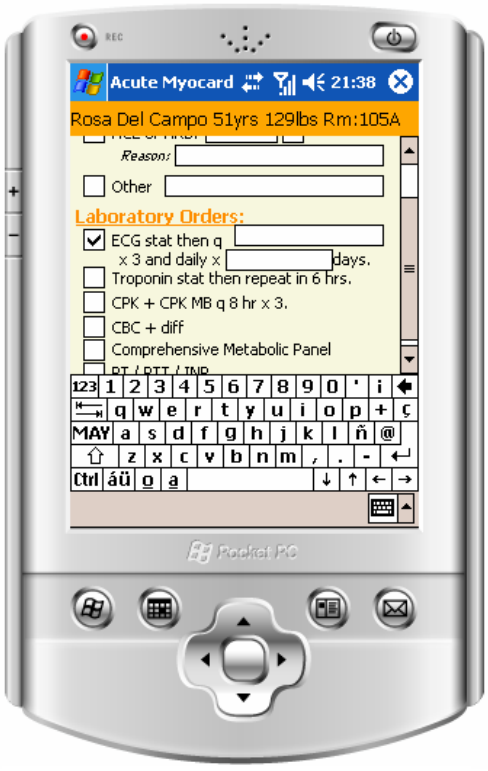

Figure 3.22c Acute Myocardial Infarction Protocol Interface

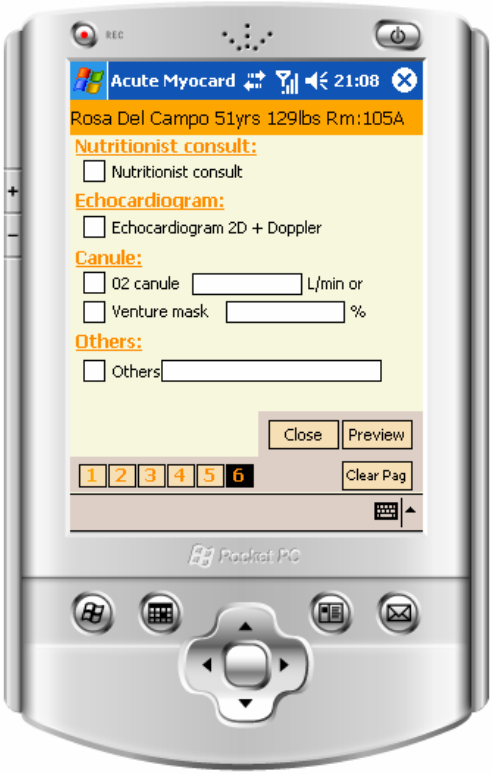

Figure 3.22d Acute Myocardial Infarction Protocol Interface

Once the user presses the Preview button, the Report of Acute Myocardial Infarction interface will be displayed (Figure 3.23a and Figure 3.23b). At the header of this window

(Figure 3.23a) the report displays relevant information of the chosen patient, such as, name, age and weight. At the bottom of this windows (Figure 3.23b) the Save and Close button is displayed. The Save button submits the acute myocardial infarction protocol order to the database. The Close button will return to the Acute Myocardial Infarction Protocol interface.

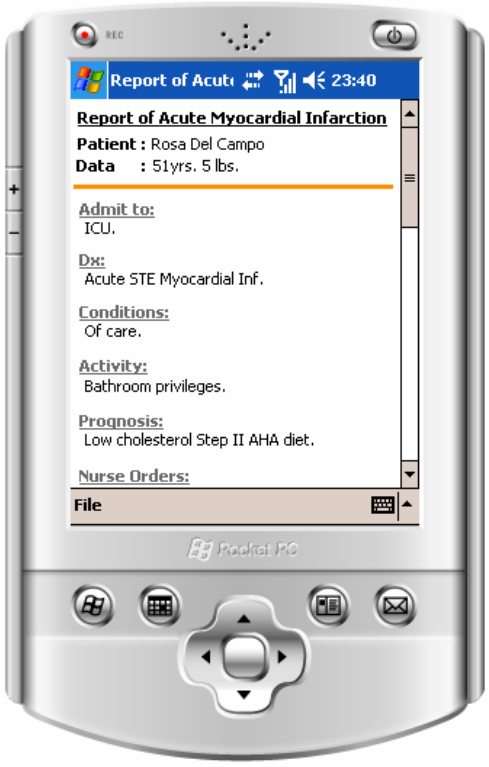

Figure 3.23a Report of Acute Myocardial Infarction Interface

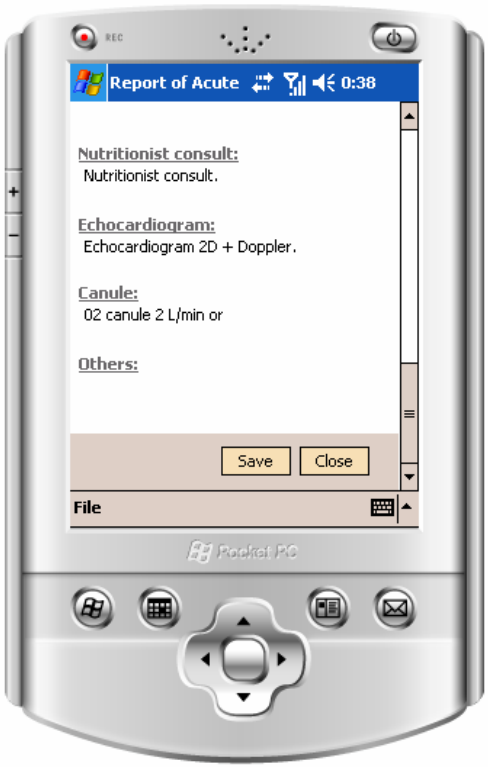

Figure 3.23b Report of Acute Myocardial Infarction Interface

3.9. Problem List Interface

The Problem List interface displays a list of previous problems that the particular patient has presented (Figure 3.24). This list specifies the problem name, the date of the beginning of the problem, and the date of the end of the problem (if any). The problem list is

ordered beginning with the current until the oldest problem, from top to bottom, to make it easy for the physicians to visualize the patient's problems. The interface also has an Add Date End button to set the end date of a particular problem of the list. This end date will be entered for the physician once the problem is resolved.

This interface also has a Close and New Problem button. To exit the interface the user must press the Close button, and to insert a new problem the user must press the New Problem button.

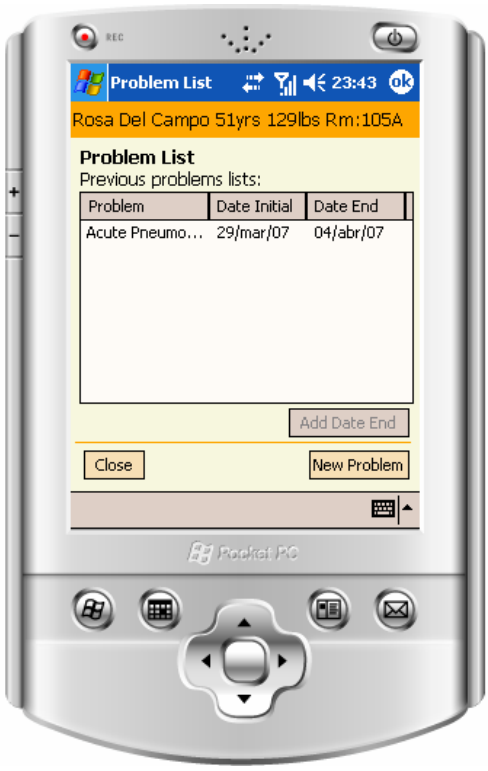

Figure 3.24 Problem List Interface

The New Problem button allows the physician to insert one or more problems to the problem list of a particular patient (Figure 3.25a). For this, the New Problem interface has a combo box that obtains the menu information from the database (Figure 3.25b). The user can

insert a new problem into the database, once done the user will be able to add the new problem to the patient. If the problem already exists in the database, the user will be able to get it from the database and assign the problem to the patient. In addition, this interface also has Delete, Add and Return button. The Delete button allows the user to remove one or more problems added to the list. The Add button allows the user to save the problems inserted into of the data base. And finally, the Return button allows the user to return to the previous interface of problem list where the updated information will be shown.

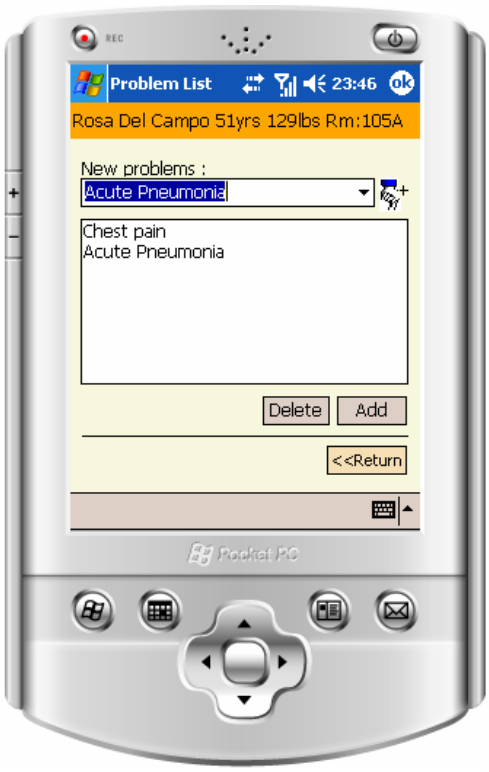

Figure 3.25a New Problem Interface

Figure 3.25b New Problem Interface

3.10. Physician's Notes Interface

The Physician's Notes interface allows the physician to view all the notes entered previously for the particular patient and to enter a new note related to their visit and the condition of the patient. When a user enters into the interface, a list of all previous notes is displayed (Figure 3.26). The list includes the date and type of the note as well as the name of the physician or nurse that wrote the note.

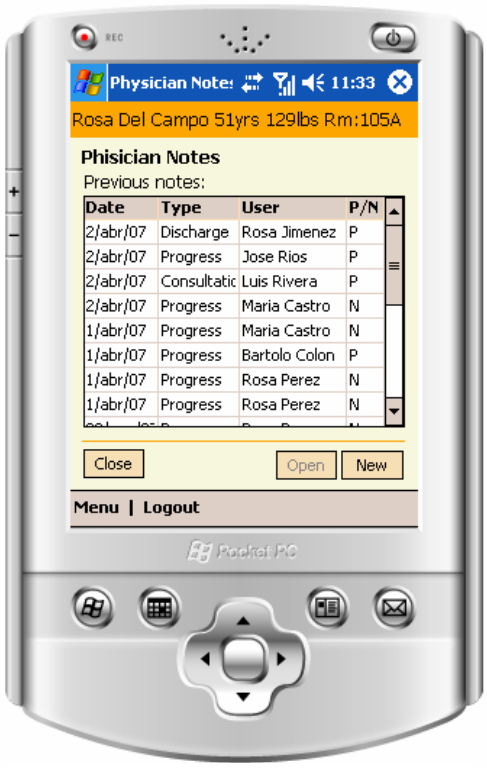

Figure 3.26 Physician Notes Interface

In order to view the complete details of a note the user must select a note and press the Open button (Figure 3.27). To enter a new note the physician must press the New button that will open the New Physician Note interface (Figure 3.28). In this interface the user must

specify a note type (initial, consultation, discharge or progress note) and the text corresponding to the note. The physician has the option of selecting the Problem List check box which will list all the active problems listed for the patient in the text area. This allows the physician to relate the note to each of the patient's problems. Finally the new note is submitted through the Save button.

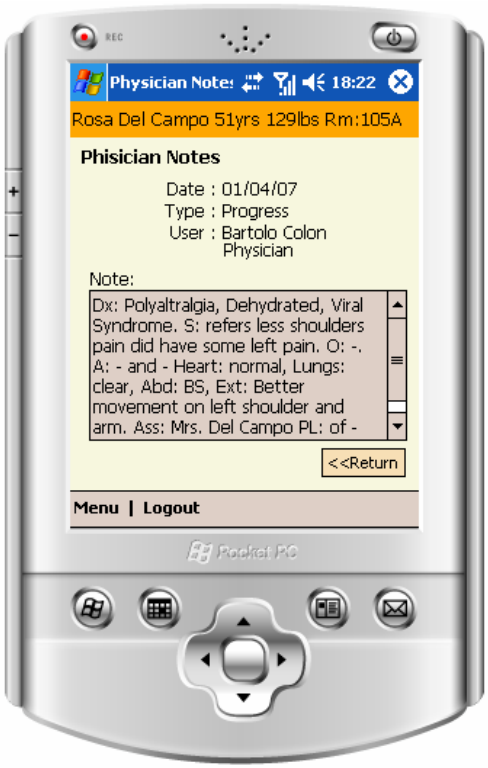

Figure 3.27 Open Physician Notes Interface

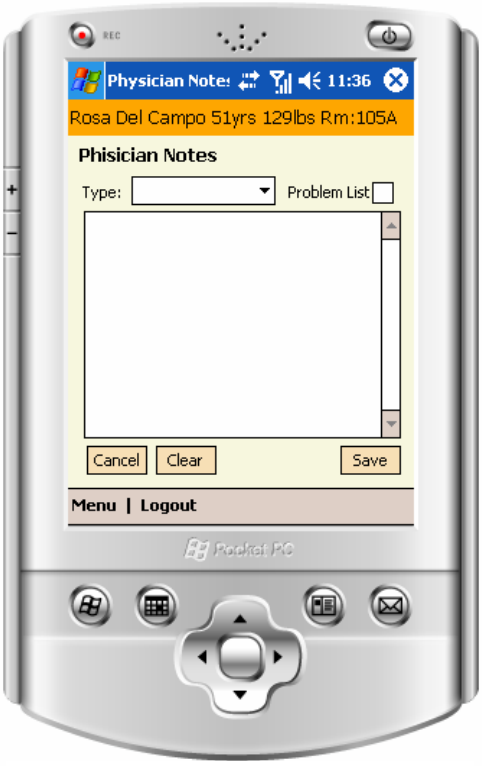

Figure 3.28 New Physician Notes Interface

CHAPTER 4, USABILITY ASPECTS

4.1. Introduction

This chapter describes some of the usability aspects considered during the design and development process of the application. These aspects are very important because they enhance the interaction of the user with the system and contribute in the improvement of the usability attributes of learnability, efficiency, memorability, reduction of errors, and user satisfaction. The usability aspects discussed in this chapter are divided in two sections. The first section describes the usability aspects applied in the early stages of analysis and design of the application and through the rest of the development process of the system. The second section describes the usability issues considered and applied in the interfaces based on the usability heuristics proposed by Nielsen [Nielsen90].

4.2. Usability Aspects in the Development Process

Usability aspects have been incorporated throughout the lifecycle of the application. To this effect several activities were conducted in the design and development process. These includes: knowing the user, conducting a task analysis of the users' activities, and applying an iterative design process with input from users and experts.

Know the User

One of the most important aspects that must be considered in any design process is to know the user. In this particular case the users are hospital physicians (specialists and

residents). To know the users, their characteristics, activities, and tasks were analyzed. Aspects such as: previous computer experience, language or terminology used, and work environment were some of the characteristic taken into account. The information was obtained from physicians at the "Centro Cardiovascular de Puerto Rico y el Caribe" and at the "Advanced Cardiology Center – Mayagüez". Both health centers were important to understand the characteristics and activities of the users as a first step of the analysis process. Part of the information obtained form the users' is shown in Appendix C.

Task Analysis

A task analysis is conducted understand all the activities realized by the users in their work. This includes every aspect related to the activities such as: the information managed, the reports and documents realized, the legal considerations, and the interaction among users. The initial task analysis for this study was conducted with physicians and health professionals of the "Centro Cardiovascular de Puerto Rico y el Caribe". The result of the tasks analysis provided important information for the design of the interfaces, navigation scheme, and database for the application.

Appendix D includes part of the results from the initial task analysis conducted. The task analysis process also included interviews with physicians and observations. Part of the outcomes of this process in included in Appendix E. The hierarchical task analysis diagrams created as a result of the task analysis process at the "Centro Cardiovascular de Puerto Rico y el Caribe" are shown in Appendix F.

Iterative Design

The main idea of iterative design is to incrementally improve and extend the functionality of an application through several cycles of a design, development, and evaluation process. During the development of the application presented, several iterative design cycles were conducted. For each version of the prototype, a usability and functionality evaluation was conducted by experts and users. This included several visits to the hospital so that physicians could evaluate the prototype.

The iterative design process helped us achieve a refined and tested product that met the expectations of the users.

4.3. Usability Aspects in the Interfaces of the Application

The following sections include several examples of how some usability aspects were considered and incorporated in the application. The sections are divided according to the usability heuristics developed by Nielsen [Nielsen90].

4.3.1. Visibility of System Status

The system should always keep users informed about what is going on, through appropriate feedback within a reasonable time [Nielsen90]. One important consideration of this aspect is to provide feedback when a process has a variable response time. If the feedback is visible, the users will know that their process is executing some action. This will make the users feel more confident about what the system is doing.

The application provides feedback to the users about their actions in the system. This feedback is shown in some cases as an indicator of a process in progress (wait cursor) and in other cases with messages that help users to understand their input to the system. In the Patient List interface, when the user selects a patient from the list, an indicator of a process in progress is shown in the middle of the interface (Figure 4.1). This indicator has colors moving in a circular way, indicating that the system is entering to another interface.

In the Personal Hygiene Order interface, a feedback message is shown when the user adds the information entered to the Visualization Tree of Orders interface (Figure 4.2). This feedback message indicates the user that an action was taken by the system.

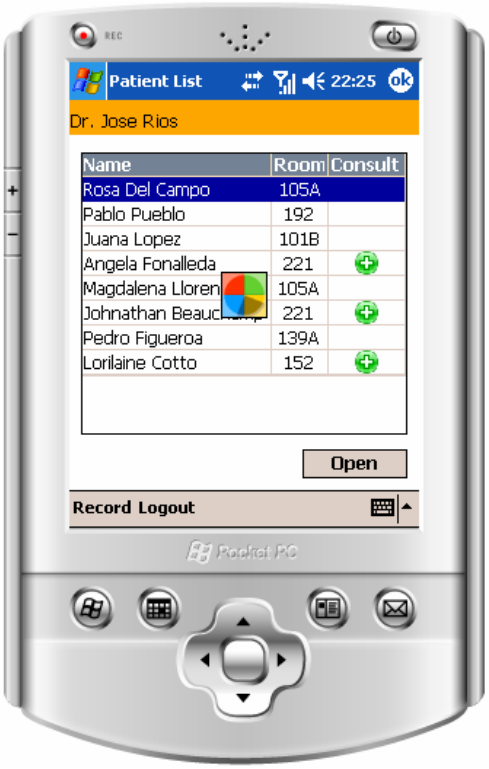

Figure 4.1 Indicator of Running Progress in the Interface

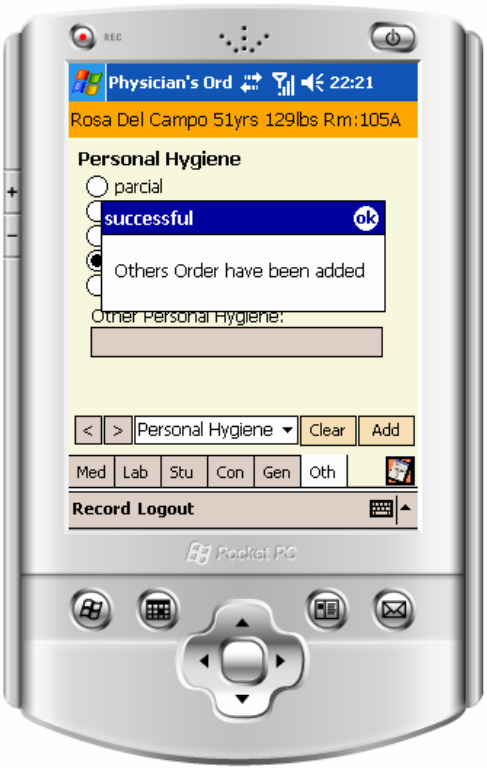

Figure 4.2 Feedback Message in the Interface

A very important issue relating feedback is to make sure users are kept informed of the state of the system and the information they are managing. Each interface of the application shows its name at the top of the interface so users are informed where they are localized in the application (Figure 4.1) (Figure 4.2). The active patient's name is also shown in top of each interface below of the name of the interface. This also includes additional information regarding the active patient such as: age, weight, and room number (Figure 4.2).

Some interfaces which consist of several pages like the Protocol interface show squares with the numbers of the pages included in the interface. These buttons, located at the bottom of the interface, are used to access the sub-interfaces or pages included (Figure 4.3). If the user presses any numbered square, then an indicator of the active page (or interface) is showed. This indicator changes the color of the square to black and the number to orange. The color of the number of these squares will become orange once the page is accessed. These features provide feedback to the users about the system status when the information is extensive and has been divided in several pages (or interface). They are aware of the active page, the pages that have been visited, and the pages remaining.

Another interface that shows visibility of system status is the Visualization Tree Order interface that summarizes and lists all the orders entered by the physicians in a particular intervention (Figure 4.4). This information is updated when the user adds, edits or deletes an order, maintaining users informed about the information entered in the medical order.

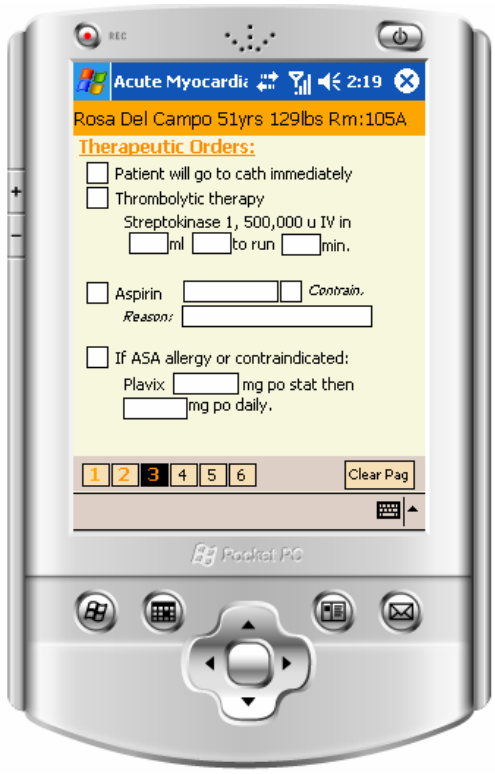

Figure 4.3 Indicator of Active Page in the Protocol Interface

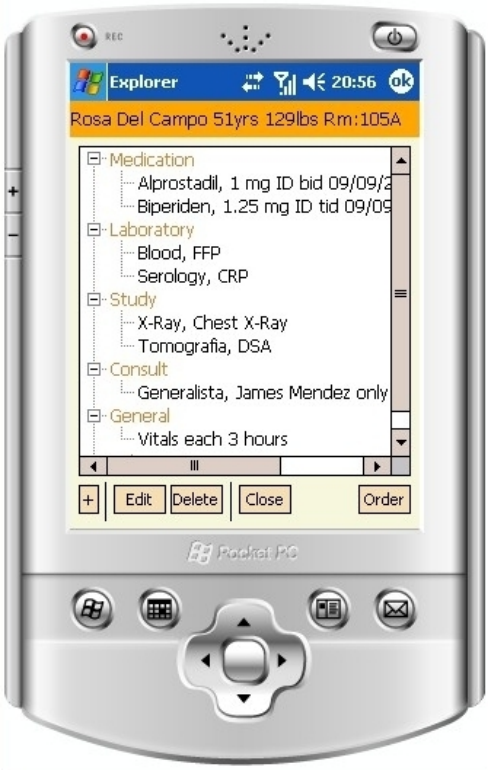

Figure 4.4 Orders Entered in the Visualization Three of Orders

Another example of feedback is the pop up window that appears as a message of error indicating incorrect user name and/or password (Figure 4.5). This feedback message will be shown until a correct user name and password are entered.

Figure 4.5 Incorrect Username and Password Message

4.3.2. Match between System and the Real World

The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than in system-oriented terms. The system should follow real-world conventions, making the information appear in a natural and logical order [Nielsen90].

The labels inside each interface of the application have the same language used by the physicians in their practice. By taking this aspect into consideration, the physicians won't feel a drastic change between their traditional paper-based documentation process and the proposed system. This usability guide will help to enhance the learnability of the system and the satisfaction of the user.

For example, to make it familiar and pleasant to the physician, the Consult Order interface has labels and radio buttons using the same language, terms, and format as the consult forms in paper used in hospitals (Figure 4.6). In the same way, the Acute Myocardial Infarction Protocol interface presents information (in six different pages) using the same language and options used in the paper form by the physician (Figure 4.7). The English language is used in all the interfaces of the physician's application since that is the language used in the paper-based documentation forms.

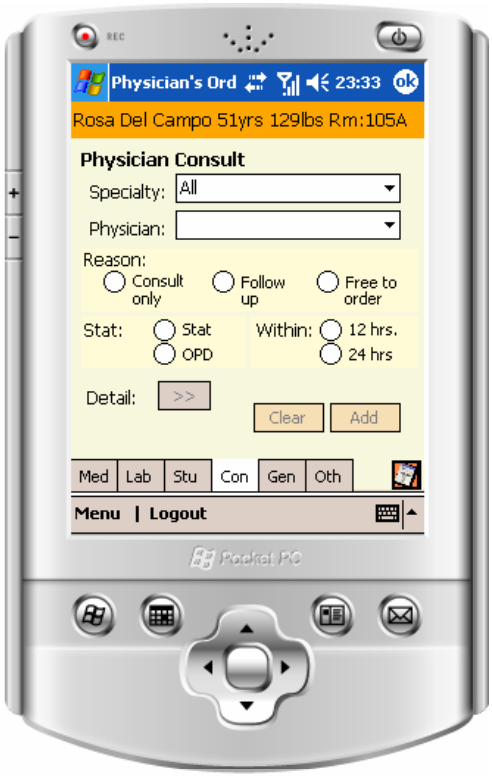

Figure 4.6 Language and Format of the Consult Order Interface

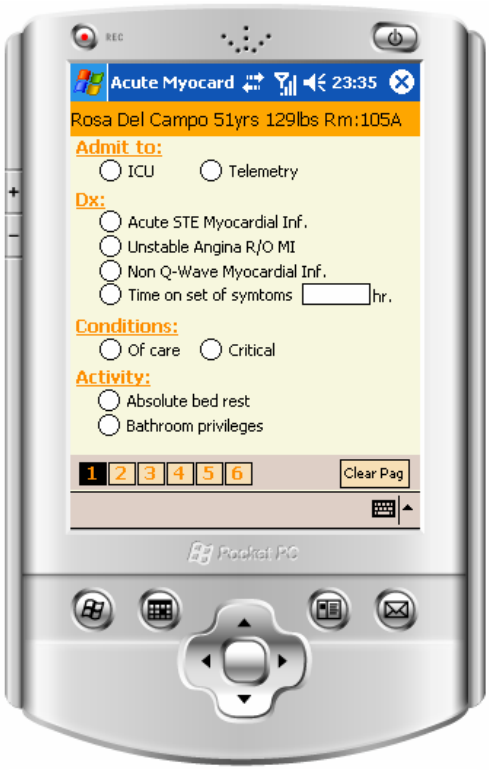

Figure 4.7 Language and Format of the Protocol Interface

4.3.3. User Control and Freedom

Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue [Nielsen90]. This aspect is very important since it avoids making the user feel trapped by the system and consequently refuse to use it.

If any option of the application is chosen by mistake, the system notifies the users and asks them if they want to continue or not with the action. This allows the users to choose the right option and gives them the confidence to use the system even if they are not experts. For example, in the Visualization Tree of Orders interface, the system allows users to edit, delete and submit the orders specified. This is very important since the physician must be sure that all medical orders are submitted without errors. The user can choose some order from the Visualization Tree and click on the Edit, Delete, or Order buttons. The systems response and messages depend on the button selected.

The response to the Edit button asks users if they want to edit that order (Figure 4.8). This message includes a detailed description of the order. For example, in the medication order shown it includes the medication name, dose, route, date and time of starting dose. If the user pushes “Yes”, the system opens the Medication Order interface and allows users to edit the information. As shown in Figure 4.9, the Delete option works in a similar fashion but by responding positively to the system’s message the order is eliminated from the Visualization Tree of Orders.

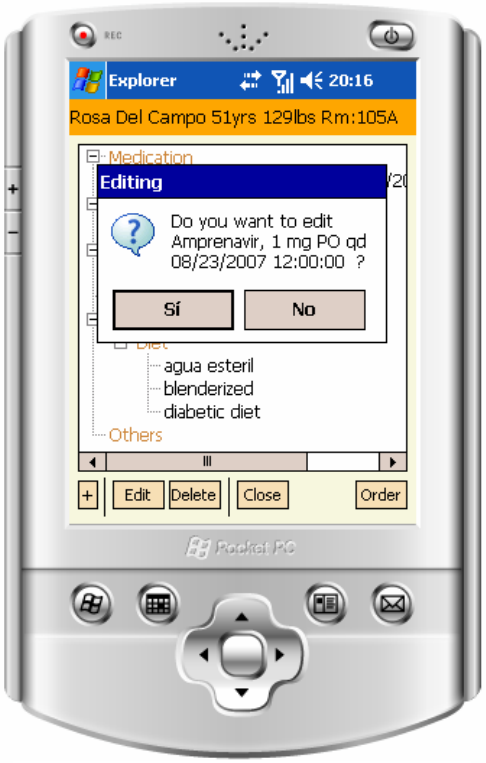

Figure 4.8 Message to Edit an Order

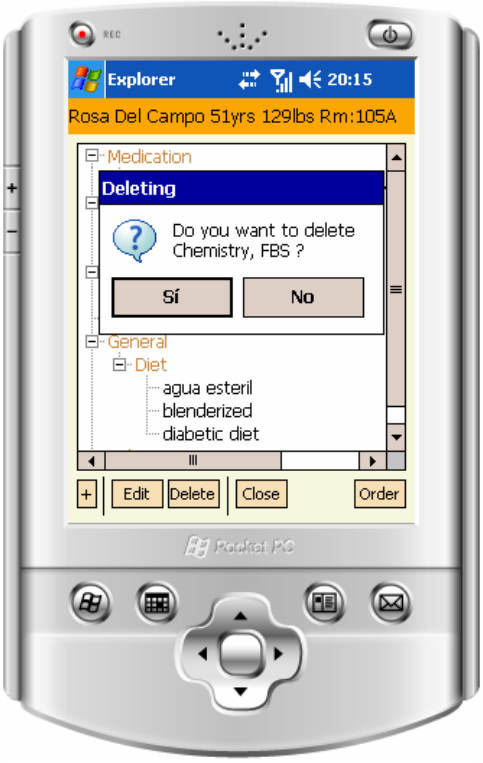

Figure 4.9 Message to Delete an Order

Finally, the user must press the Order button to submit the complete order. The message associated with this option is shown in Figure 4.10. If the user responds “Yes” to the dialogue question, then all the orders will be submitted and saved in the database.

Another important example of user control and freedom is illustrated when the user wants to exit the Physician’s Order interface (Figure 4.11). This control appears as message when the user doesn’t submit the orders and has pending orders. If the user pushes “Yes”, then the orders that had been entered until the moment will be lost. Otherwise, by selecting “No” the user remains in this interface

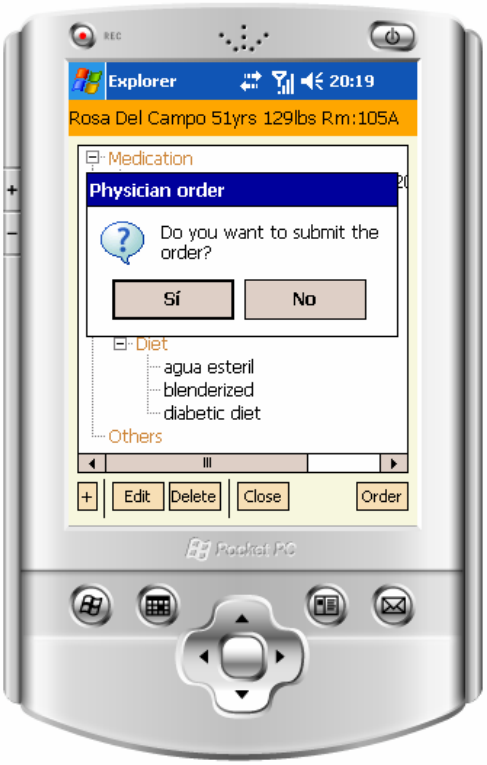

Figure 4.10 Message to Submit an Order

Figure 4.11 Pending Order Message

4.3.4. Consistency and Standards

Users should not have to wonder whether different words, situations, or actions mean the same thing [Nielsen90]. The user will feel more confident in using the system if the interfaces present an adaptive behavior. This aspect will help the users recognize the commands and actions in the system, and consequently prevent errors and enhance their learning process.

For example, the Laboratory Order and Study Order interfaces are very similar (Figure 4.12 and Figure 4.13); the radio buttons, labels and combo boxes of these two interfaces are presented in an aligned way, showing symmetry between both. This aspect is

presented in some interfaces of the application. This allows the user to be familiarized and learn more easily the application. In addition, some aspects such as the navigation tabs, the buttons to add and clear orders, and the buttons to write additional details have the same name, form, and functionality in all the interfaces.

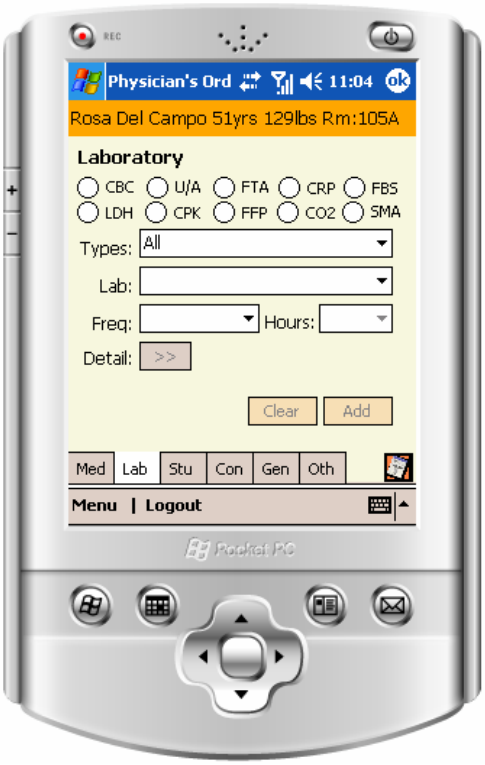

Figure 4.12 Consistency in the Laboratory Order Interface

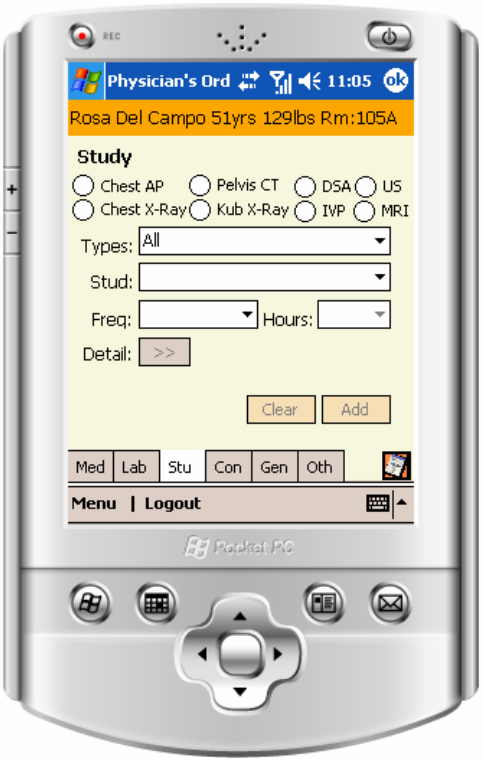

Figure 4.13 Consistency in the Study Order Interface

4.3.5. Error Prevention

Even better than good error messages is a careful design which prevents a problem from occurring in the first place [Nielsen90]. The design of a system must help users avoid

situations of potential errors. These potential errors must be recognized by the system and the users before becoming a problem. It is always better to prevents errors than handling them.

The application verifies the state of the system and information entered before taking important actions like saving data in the database. Some examples of error prevention are the pop-up messages shown to the user. These inform the user the situation in the system and help prevent errors. For example, in the tab of General Order, the Diet Order interface verifies if a diet has been specified (Figure 4.14). In case the diet had already been added in the order, a message will be displayed, not allowing the entrance of redundant data to the system.

Another type of error prevention incorporated into the system is shown in the Medication Order interface. After the users enter a medication order the system validates that the starting date is previous to the final date (Figure 4.15). If this is not the case, a message is displayed indicating the error and forcing the user to insert a correct date. This guarantees that the system accepts only consistent data, and thus preventing errors.

Figure 4.14 Redundant Data Error Message

Figure 4.15 Mistake of Date Error Message

4.3.6. Recognition Rather than Recall

Make objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate [Nielsen90]. Taking this into account will make users feel comfortable and will enhance the learnability and memorability attributes of the system.

In order to reduce the memory load of users, the application of this project includes simple, visible, and consistent actions or operations. For example, the interfaces that are composed for several sub-interfaces have two different ways to access to each sub-interface.

One way is through buttons represented by arrows that allow users to select the previous page or the next page. Another way is by selecting the sub-interface from a combo box. This allows the user to select the interface by name. One example of this type of interaction is used in the Others Order interface (Figure 4.16).

Due to the small size of the screen of the PDA, there is text that has to be abbreviated. To compensate for this, the system implements automatic hints that shows the complete text. For example, the Restraint Order interface indicates at the header of the interface the complete text representing the reason for restraints that is show abbreviated in the form (Figure 4.17).

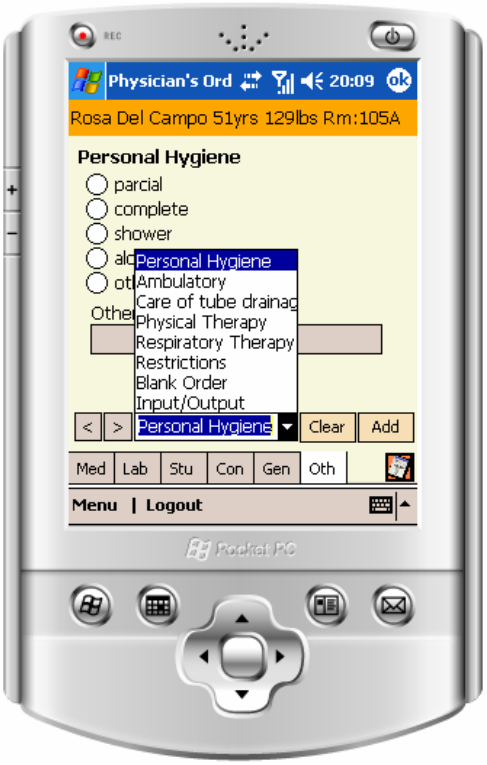

Figure 4.16 Navigation in several sub-Interfaces

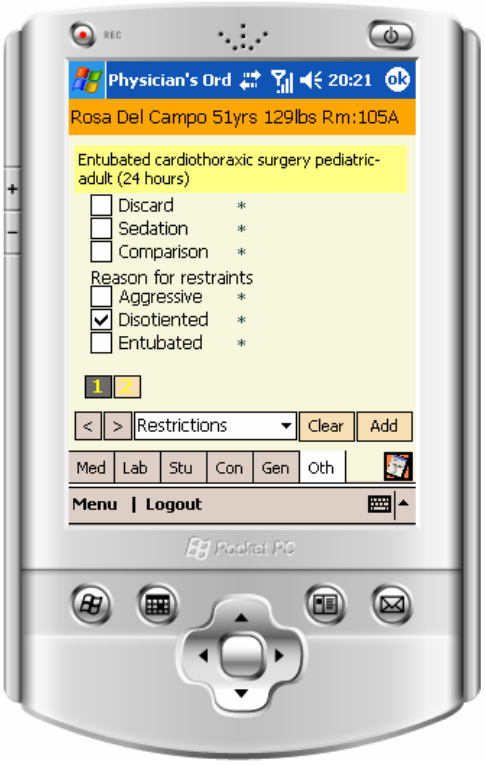

Figure 4.17 Automatic Hint in the Interface

Another example is the Visualization Tree of Orders interface. This interface has a button with the symbols of plus and less located in the left bottom corner. This button allows the user to expand or to collapse the Tree of Orders (Figure 4.18 and Figure 4.19). This action makes it easier for the user to see the orders on each branch of the tree. In addition, this option helps the user to view the complete order in spite of the small size of the PDA screen.

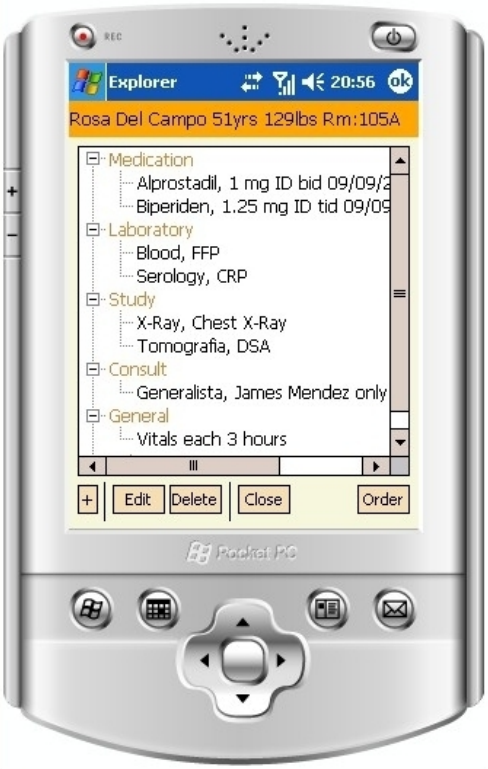

Figure 4.18 Expand the Visualization Three of Orders

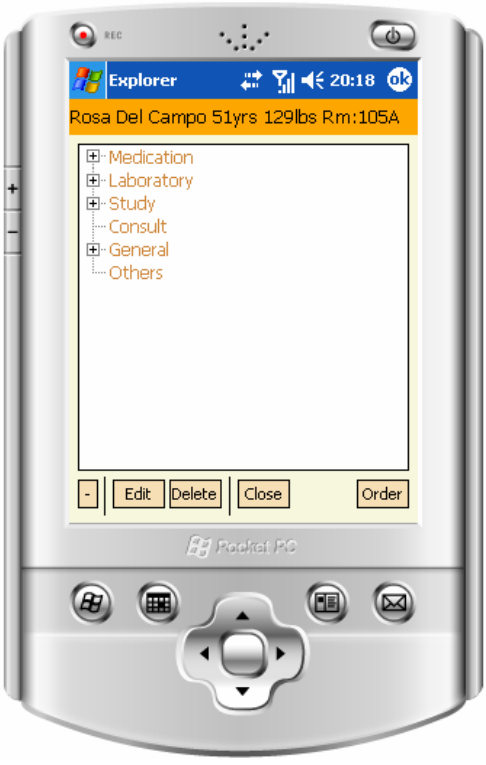

Figure 4.19 Collapse the Visualization Three of Orders

4.3.7. Flexibility and Efficiency of Use

Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users [Nielsen90]. The satisfaction of the expert and non-expert users can also be measured by the speed in which their actions are performed in the system. This system must include alternate ways to access and recover information quickly. Aspects such as entry of data to the system by selection without the use of keyboard enhance user's satisfaction and improve efficiency.

To facilitate the user interaction the application includes many automatic actions. For example, each text box that is activated opens the system's keyboard automatically (Figure 4.20). Depending if the data of the text box is alphanumeric or numeric, the keyboard changes accordingly. This automatic access to the keyboard allows the user to insert data faster.

In addition, the Vertical Scroll of the interface is activated when the opened keyboard hides part of the text or interface components of the active form (Figure 4.21). This prevents the keyboard from interfering with the entrance of data and allows the visualization of the complete interface.

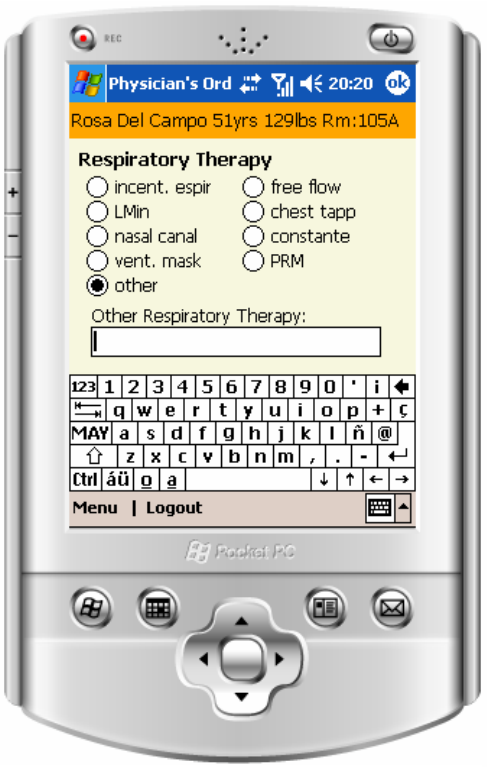

Figure 4.20 Automatic Input Panel in the Interface

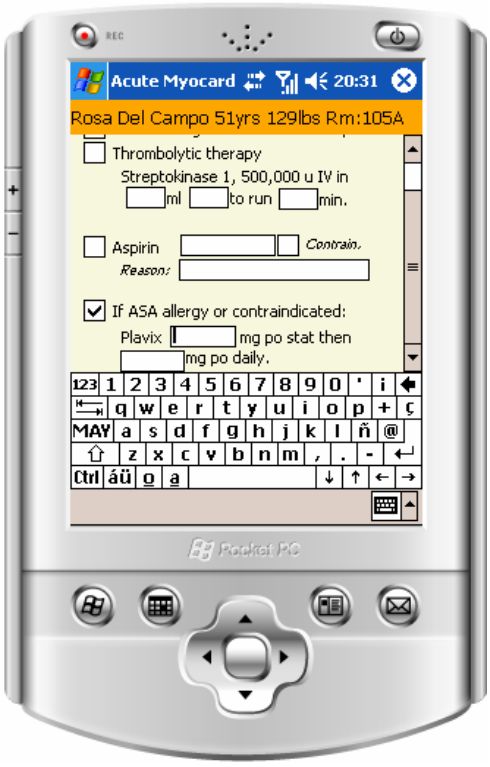

Figure 4.21 Automatic Vertical Scroll in the Interface

Another example of shortcuts is shown in the Laboratory Order and Study Order interface (Figure 4.12) (Figure 4.13). These interfaces provide users the option to choose the most common laboratories and studies respectively by means of radio button located at the top of the interface. This option allow users to quickly and directly specify the required information of laboratory and study instead of having to choose from the lists of the combo boxes according to type or classification. This option offers flexibility and efficiency to physician speeding up the use of the application.

4.3.8. Aesthetic and Minimalist Design

Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility [Nielsen90]. A minimalist design should avoid cluttering the interfaces with unnecessary information. For example, the Summary interface contains only the necessary information for the physicians (Figure 4.22). According to the interviews conducted with physicians, the information displayed is what they felt was necessary before their intervention with the patient. The information is shown in a sorted and aesthetic way.

Another example of this aspect is illustrated in the Diagnosis interface (Figure 4.23). This interface shows a clear and specific message about the situation of the system. In this case, the message indicates to the user that the diagnosis has already been selected. This message has a minimalist design with a dialog window that is not cluttered.

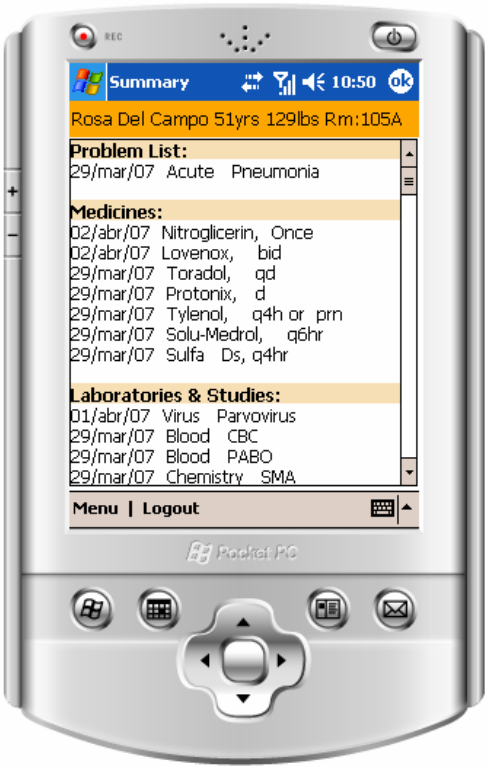

Figure 4.22 Design of Summary Interface

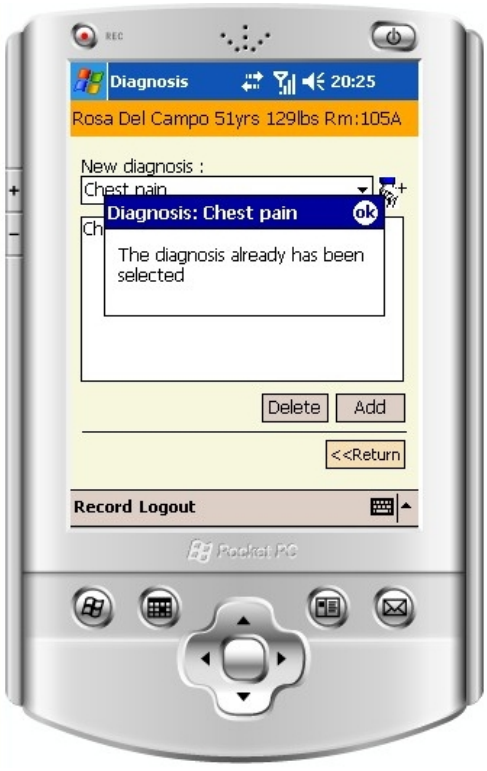

Figure 4.23 Design of Medication Order Interface

4.3.9. Help Users Recognize, Diagnose, and Recover from Errors

Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution [Nielsen90]. The users' comfort with the system is reflected when they are able to recover from errors. The user must not feel stuck or intimidate by the error messages when they make a mistake.

The interfaces of the application for physicians show messages to the user indicating different actions. These messages use simple and plain language to help users recognize errors. In addition, these messages include enough information to allow users to know what are the errors and the way to recover from them.

For example, in the Medication Order interface (Figure 4.24), if the user pushes the Add button to store the order temporarily on the Visualization Tree of Orders, then the system will verify that all the necessary data has been entered. In case the data is incomplete, a notification message of incomplete data is shown reminding the user to complete the entrance of data. In Figure 4.24, the dose entrance is necessary for a medication order.

The Medication Order interface also displays other messages of notification in case of lost data (Figure 4.25). If the user chooses another tab after entering data on the tab of Medication Order without adding the order to the Visualization Tree of Orders, the message of lost data will be shown, permitting the user to either discard or add the medication order.

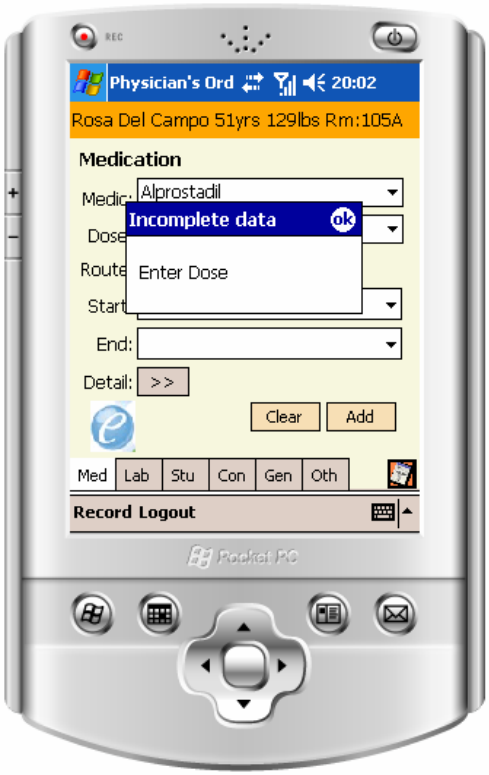

Figure 4.24 Incomplete Data Message

Figure 4.25 Lost Data Message

CHAPTER 5, USABILITY EVALUATION

5.1. Introduction

The number of people using software for PCs, electronic devices, and internet has incremented. This increase in users makes the usability of the software one of the most important factors when a product is designed and developed. A good usability applied to the software will result in increased user satisfaction and subsequently in the success of the product reflected in the merchandising of the software.

According to ISO standard, there are two documents issued by the International Organization for Standardization that define the term usability. The document ISO 9126 (1991) Software Engineering Product Quality defines usability as: “A set of attributes that bear on the effort needed for use, and on the individual assessment of such use, by stated or implied ser of users”. The second document, ISO 9241-11 (1998) Guidance on Usability, defines usability as: “The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use” [Ferre01]. The usability is a specific aspect of a system associated with the functionality of the product. It differs depending on the intended use of the system under development [Ferre01].

Because usability is a term too abstract to study directly, it is usually divided into attributes [Ferre01]. These attributes are learnability, efficiency, user retention over time, error rate, and satisfaction. The detailed definition of each attribute is shown in the Table 5.1.

Table 5.1 Usability Attributes [Ferre01]

1. Learnability
How easy it is to learn the main system functionality and gain proficiency to complete the job. Usually assess this by measuring the time a user spends working with the system before that user can complete certain tasks in the time it would take an expert to complete the same tasks. This attribute is very important for novice users.
2. Efficiency
The number of tasks per unit of time that the user can perform using the system. We look for the maximum speed of user task performance. The higher system usability is, the faster the user can perform the task and complete the job.
3. User retention over time
It is critical for intermittent users to be able to use the system without having to climb the learning curve again. This attribute reflects how well the user remembers how the system works after a period of nonusage.
4. Error rate
This attribute contributes negatively to usability. It does not refer to system errors. On the contrary, it addresses the number of errors the user makes while performing a task. Good usability implies a low error rate. Errors reduce efficiency and user satisfaction, and they can be seen as a failure to communicate to the user the right way of doing things.
5. Satisfaction
This shows a user's subjective impression of the system.

A usability evaluation is a method used to understand the usability of the product and identify problems and issues that are necessary to improve. This usability evaluation must be designed to measure the usability of a product from a user's point view. The Table 5.2 lists and defines several Usability Evaluation Methods (UEMs). Each one has different synopsis, advantages, and disadvantages. Each one can be applied according to the necessity and scope that one wants from the product, evaluating limitations as time, budget, and user availability. One or more of these methods can be chosen and applied throughout the development of the product.

Table 5.2 Usability Evaluation Methods (UEMs) [Nielsen94]

1. Think Aloud User Testing (Performance Testing)
Form of user testing where one user's interaction with a product is videotaped and analyzed to improve the product.
2. Constructive Interaction
Form of user testing where two users interaction with a product is videotaped and analyzed to improve the product.
3. Focus Groups
Form of data gathering, usually used during the product conceptualization phase in the product cycle where potential users are asked for their opinions on a potential product.
4. Expert Review (ER)
People having sufficient experience or an advanced degree in a related discipline (HCI experts) critique a product separately or in groups to determine areas in need of improvement.
5. Expert Walkthrough (EW)
HCI experts use task scenarios to guide their analysis of the interface.
6. Heuristic Evaluation (HE)
HCI experts separately review an interface and categorize and justify problems based on a short set of heuristics (rules of thumb).
7. Heuristic Walkthrough (HW)
Similar to the above definition except task scenarios are used to guide the analysis.
8. Guidelines (G)
Guidelines range from several hundred items to roughly a thousand. A guidelines analysis judges whether an interface conforms to these rules.
9. Guidelines Walkthrough (GW)
Uses the above mentioned guidelines but uses task scenarios to guide the analysis.
10. Cognitive Walkthrough (CW)
A method which fully utilizes task scenarios to stress the user's cognitive process and model, which guides the analysis.

The Heuristic Evaluation (HE) is a usability evaluation method developed by Nielsen and Molich [Nielsen90] as a usability tool to achieve effective results with little time and limited resources. This method involves several experts in the area of Human Computer Interaction (HCI) and Usability Engineering, whom evaluate the software following a guide denominated usability heuristics. The main advantage of this method is that the system is evaluated by experts and that you can obtain valuable information for corrections in the system on reasonable fast time and low cost.

The usability heuristics are the guides used for the heuristic evaluation and consists of ten general principles for a user interface design (Table 5.3). These principles are called “heuristics” because they are more in the nature of rules of thumb than specific usability guidelines [Nielsen90]. The detailed definition of each heuristic is shown in the Table 5.3.

Table 5.3 Usability Heuristic [Nielsen90]

1. Visibility of system status
The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
2. Match between system and the real world
The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
3. User control and freedom
Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.
4. Consistency and standards
Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
5. Error prevention
Even better than good error messages is a careful design which prevents a problem from occurring in the first place.
6. Recognition rather than recall
Make objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
7. Flexibility and efficiency of use
Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
8. Aesthetic and minimalist design
Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
9. Help users recognize, diagnose, and recover from errors
Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
10. Help and documentation
Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation.

5.2. Procedure of the Heuristic Evaluation

The chosen method to perform the usability evaluation for the application developed in this project was the heuristic evaluation. The evaluation was conducted by five experts in Human Interaction Usability (HCI) and Usability. Before conducting the evaluation, the evaluators were given an orientation about the purpose of the evaluation and of their role like evaluators (Appendix G). Subsequently, they approved their participation in the evaluation by means of the user's consent form (Appendix H). A short training regarding the functionality of the system was developed and given to the evaluators.

With the purpose of helping the evaluator to exercise the system and identify usability problems, evaluators were giving a list of tasks of the system to be used during their evaluation (Appendix I). The tasks were chosen according to the commons activities of the physician during a day of attention to a patient. These tasks are the following:

1. Identify the patients' names that the physician must assist for consultation.
2. Enter to the record of the patient named Rosa Del Campo.
3. Determine the patient's age and weight.
4. Determine the most recent registered patient's temperature.
5. Enter the following set physician's orders:
    - Medicine: Lasix, 40 mg, IV, q12h, start today until 21 of the month.
    - Laboratory: CBC of "Blood".
    - Laboratory: PT control of "Coagulation Hematology".
    - Other order: Input & output.

- General orders: Vital signs every 2 hours.
- Other order: Care of chest tube drainage.
- General orders: Low cholesterol diet.
- Consultation: Physician Bartolo Colón of Endocrinology for recommendations in the management of hypothyroidism.
- Remove the laboratory order of PT Control of Coagulation Hematology.

6. Save all the physician's orders entered.
7. Determine all the medications given to the patient.
8. Look for the consultation note carry out for Dr. Luis Rivera to the patient named Rosa Del Campo.
9. Write the following note of progress of the patient named Rosa Del Campo: "Pt presents irregular HR and CHF caused by HTN"

The objective of the evaluation conducted by each evaluator was to identify the usability problems and their level of severity. The levels of severity were given from the level one to level five, where level one represents a cosmetic error without a lot of consequence and level five represents a catastrophic error. For this reason, in order to gather the valuable information to be analyzed evaluators were given a form to fill out the usability problems and their severity level. The Table 5.4 shows the levels of severity (severity rating scale) considered for the heuristic evaluation.

Table 5.4 Levels of Severity for the Heuristic Evaluation [Nielsen94]

Severity 1. Cosmetic
Will not affect the usability of the system, fix if possible.
Severity 2. Minor
Users can easily work around the problem, fixing this should be given low priority.
Severity 3. Medium
Users stumble over the problem, but quickly adapt to it, fixing this should be given medium priority.
Severity 4. Major
Users have difficulty, but are able to find workarounds, fixing this should be mandatory before the system is launched. If the problem cannot be fixed before launch, ensure that the documentation clearly shows the user a workaround.
Severity 5. Catastrophic
Users are unable to do their work, fixing this is mandatory

5.3. Results of the Heuristic Evaluation

The following tables contain the results of the heuristic evaluation for each of the evaluators.

Table 5.5 Usability problem identified by evaluator 1

#	Usability problem	Severity
1	The option to sort the data from the patient's list is not visible at first time.	**3**
2	Focus is missing when a detail of the physician's consultation order is made.	**1**
3	Irrelevant information is showed in detail interface of the physician's consult interface.	**1**

Table 5.6 Usability problem identified by evaluator 2

#	Usability problem	Severity
1	The last vital sign of the patient's summary interface is difficult to see.	**2**
2	Feedback does not exist when adding an order on any physician's order interface.	**2**
3	A name does not exist for the type and classification of the diet order interface.	**1**
4	The return button is not evident on physician's consult order interface.	**1**
5	The consultation option of the menu and the physician's consult order seem to be the same option, but they are different.	**3**

Table 5.7 Usability problem identified by evaluator 3

#	Usability problem	Severity
1	The color of the interface top where the patient's information is very strong and does not allow seeing the data well.	**1**
2	The date calendar of the medication order interface is not sensitive and exist difficulty when a date is chosen.	**2**
3	The feedback message when any order is performed does not provide details of the order as name, date or amount.	**1**
4	The name of type and classification of diet of the diet order interface does not exist.	**2**

Table 5.8 Usability problem identified by evaluator 4

#	Usability problem	Severity
1	The logout option in the patient list interface doesn't work.	**1**
2	The frequency data of the medication order interface is redundant.	**1**
3	The icon of the order tree is very small and is not evident.	**1**
4	The start and end dates of the medication order interface doesn't work correctly.	**2**

Table 5.9 Usability problem identified by evaluator 5

#	Usability problem	Severity
1	When changing a tab to another, the physician's order interface does not keep the information entered in any tab if this information has not been saved.	**2**
2	The icon of the orders tree is not evident,	**2**

These levels of severity are indicators of the importance of the usability error that must be fixed to improve the application. According to the information of the heuristic evaluation from the five evaluators, 18 usability problems were identified. Table 5.9 summarizes these problems grouped according the level of severity.

Table 5.10 Usability Problems by Level of Severity

Severity	# Usability Problems
1	9
2	7
3	2
4	0
5	0
Total	**18**

5.4. Redesign of the Application

Based on the results of the heuristic evaluation some interfaces of the application were redesigned or modified. These improvements in the application were performed in order to their severity. A summary of the changes made follows:

1. The name of the consultation option of the menu was changed to distinguish it from the option of the physician's consult order.
2. The date calendar of the Medication Order Interface was corrected and validated so that it works correctly.
3. The logout option in the patient list interface was enabled.
4. The redundant information of medicine frequency label in the Medication Order Interface was eliminated.
5. The name of the type and classification of a diet in the Diet Order Interface was added.

6. The last vital sign of the patient’s summary interface was changed to capital letters to make it more visible to the user

According to the usability heuristic evaluation, the identified problems didn't have a high level of severity. The maximum severity rating given to any usability fault was a 3. In addition, the 18 usability problems identified by the evaluators have been considered for improving the application.

It is important to conduct usability evaluations through the development process, since the problems can be identified and solved at an early stage. The usability heuristic evaluation conducted has demonstrated to be a simple and inexpensive method that provided relevant information, useful for improving the interfaces of the application.

CHAPTER 6, CONCLUSION AND FUTURE WORK

6.1. Conclusion

The main goal of this project was to develop a PDA based application to support physician's tasks at the point of care in hospitals. This development included the analysis, design, implementation, evaluation, and documentation of the application. This application developed for a Windows Pocket PC device, is based on a task analysis conducted with physicians from the "Centro Cardiovascular de Puerto Rico y el Caribe" and the "Advanced Cardiology Center - Mayagüez". The information of these medical centers was of vital importance in order to know, understand, and capture the daily activities that physicians carry out during the direct interaction with their patients at the point of care in hospital.

This application presented provides support for most of the physician's documentation requirements. Most important is the ordering module that includes different types of medical orders such as: medication, laboratory, studies, diets, and vital signs. Throughout the development process, several evaluations and consultations were conducted with physicians from the institutions mentioned previously. This helped to improve and clarify the panorama during the development of the system. With these visits to the physicians and with their opinions and evaluations, the system become an application that matched the real world, since according to the impressions of these physicians the system was improved and adjusted to their necessities. Also, the application was designed in such a way that can be easily implemented in other hospitals.

In order to offer a better tool to physicians, the system has a reciprocate interaction between physicians and nursing modules that can be seen in some interfaces of the application as Summary, Notes, and Consultation. The interaction with the nursing module developed previously in another project makes the developed application a useful tool, since it is part of a complete electronic medical record system.

The heuristic evaluation conducted on the application resulted in few usability problems with low severity rating. Thus, we conclude that the application does not have significant problems of usability. This result supports the principle that the incorporation of usability principles through all stages of the development process results in a more usable product.

Software for portable devices, such as the PDA, is commonly used among physicians in hospitals. This indicates that physicians are probably accustomed to this type of technology and that a PDA based system can potentially be implemented in any hospital. For this reason, based on the development of this application and the growth of PDA technology in hospitals, we affirm that this device won't be an obstacle as part of a clinical documentation application to perform physicians' task related to patient care. This aspect makes the application an important and very useful tool for the physicians in the hospitals in Puerto Rico.

Health care management and medical informatics are a complex, data intensive, interaction intensive, and variable process. The application developed in this project demonstrates that with careful design and usability considerations PDA-based systems are a viable alternative or compliment for such complex environments. Their portability and

wireless technology are important aspect that can help, improve, and simplify the physician's task at the point of care.

6.2. Future Work

The most important future work is to conduct a full usability study of the application with physicians' direct interaction during a normal day of their activities at the point of care. Such a study should include a complete analysis of the interaction between physicians and the system.

In addition, a comparative study can be performed between two versions of the application to support physicians' tasks at the point of care. A comparison should be conducted between the PDA based application of this project and another Tablet PC based application developed by another research assistant of the project. The goal would be to identify potential usability problems, interaction differences, advantages and disadvantages among both versions.

Finally, taking into account that a PDA based nursing application exists, a usability study conducted with physicians and nursing interacting with their respective PDA based documentation applications should be considered. This study would evaluate the behavior of both applications with the same database and by means of wireless technology.

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APPENDIXES

APPENDIX A

General Orders Interfaces

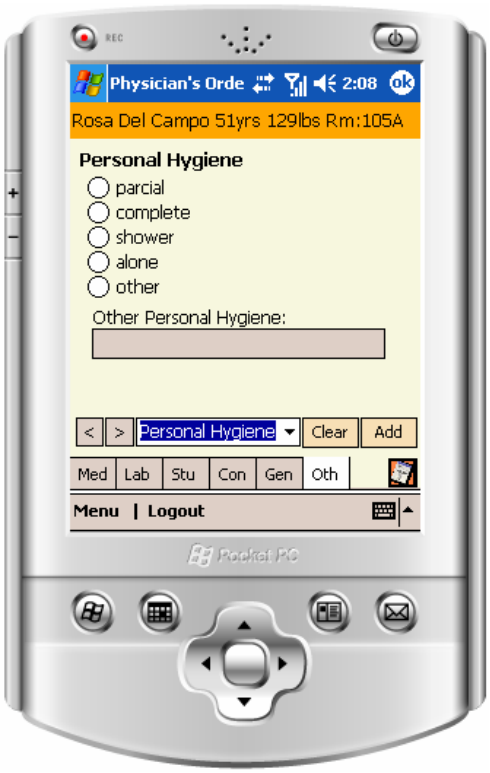

Figure A.1 Personal Hygiene Order Interface

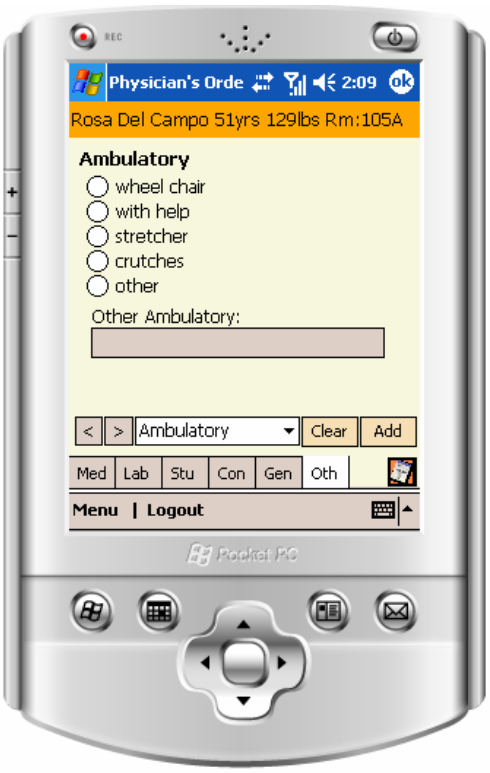

Figure A.2 Ambulatory Order Interface

Figure A.3 Respiratory Therapy Order Interface

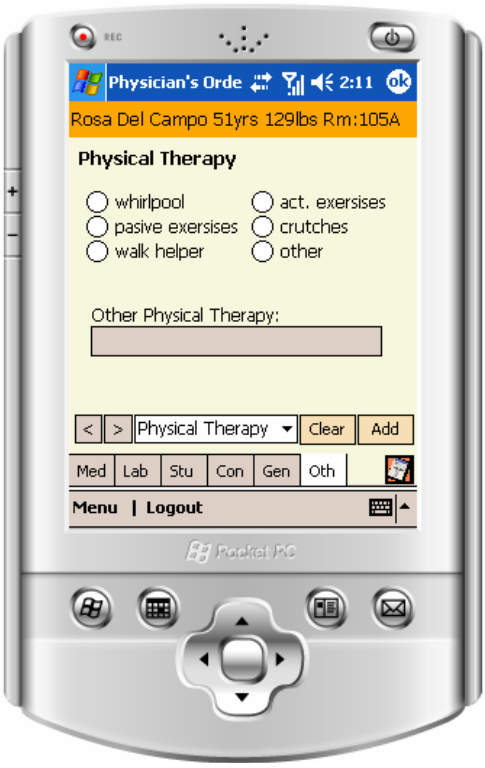

Figure A.4 Physical Therapy Order Interface

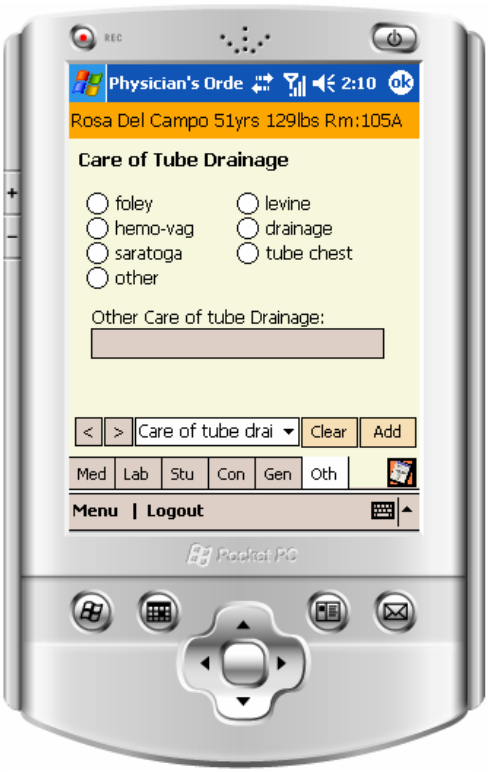

Figure A.5 Care of Tube Drainage Order Interface

Figure A.6 Restraint Order Interface (page 1)

Figure A.7 Restraint Order Interface (page 2)

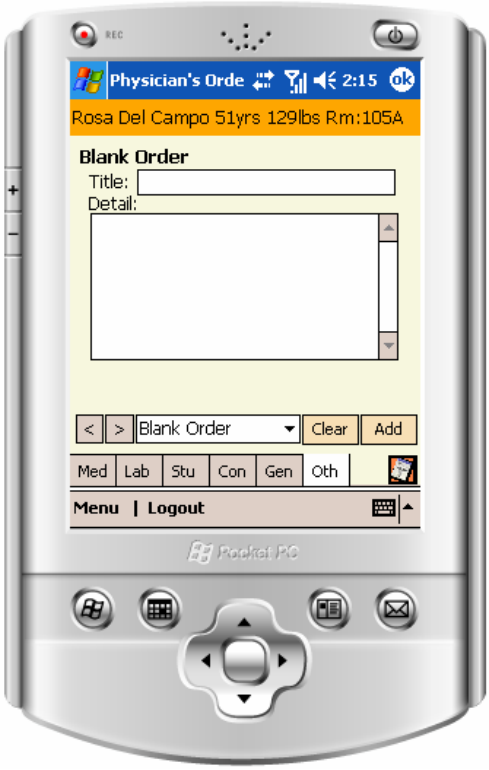

Figure A.8 Blank Order Interface

APPENDIX B

Protocol Orders Interfaces

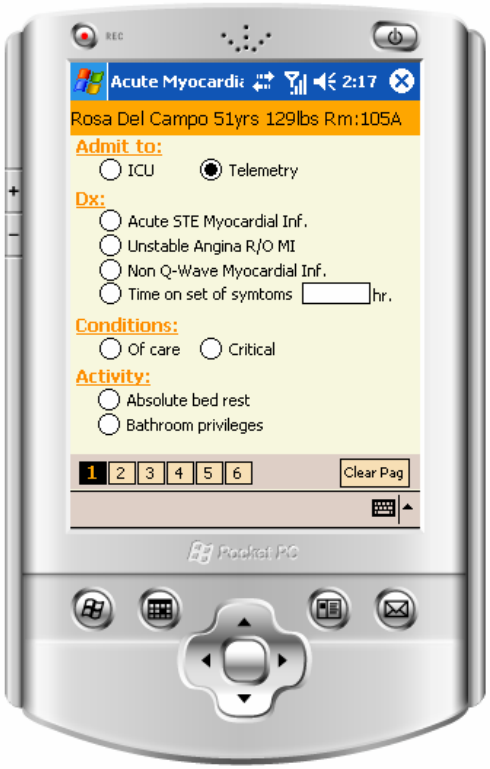

Figure B.1 Acute Myocardial Infarction Interface (page 1)

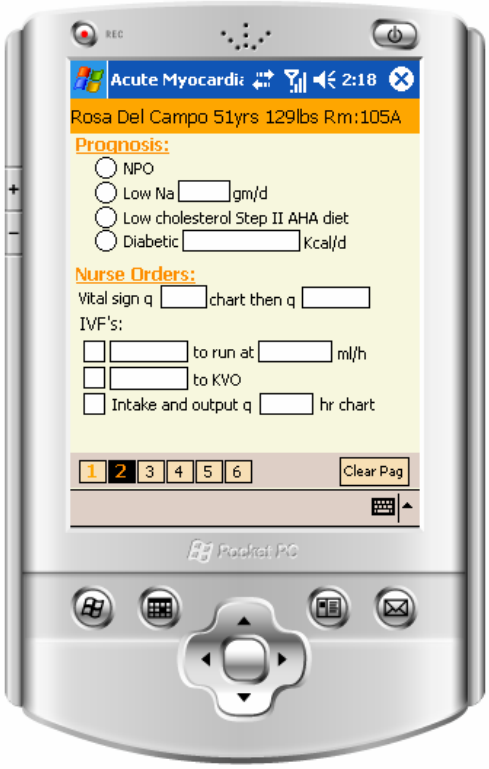

Figure B.2 Acute Myocardial Infarction Interface (page 2)

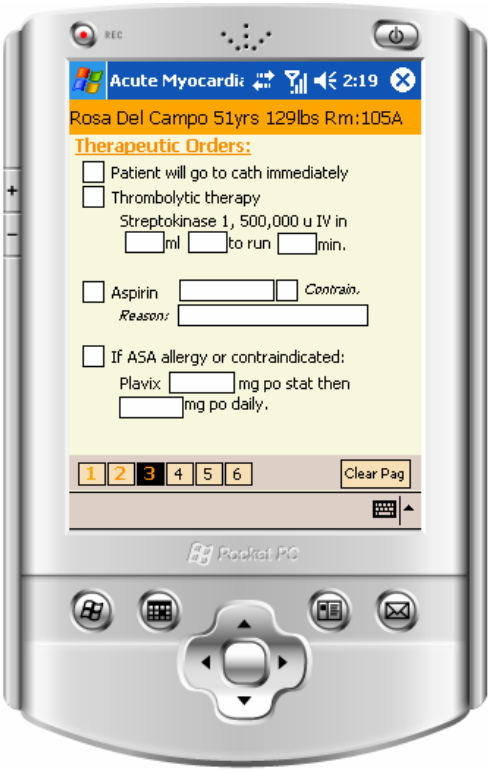

Figure B.3 Acute Myocardial Infarction Interface (page 3)

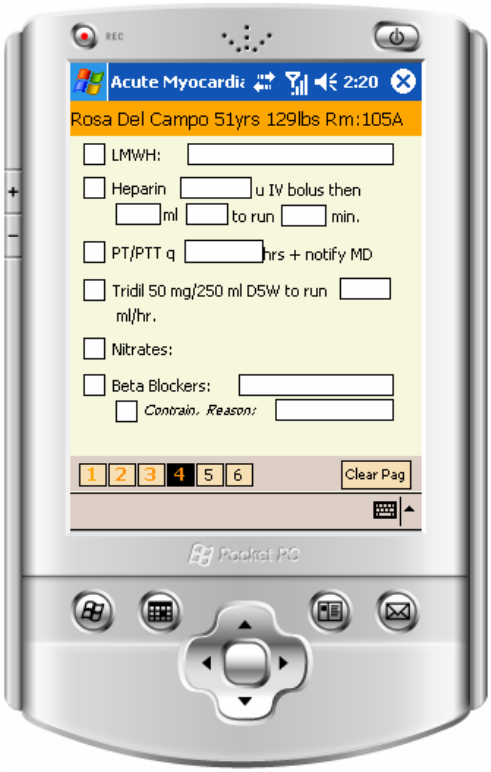

Figure B.4 Acute Myocardial Infarction Interface (page 4)

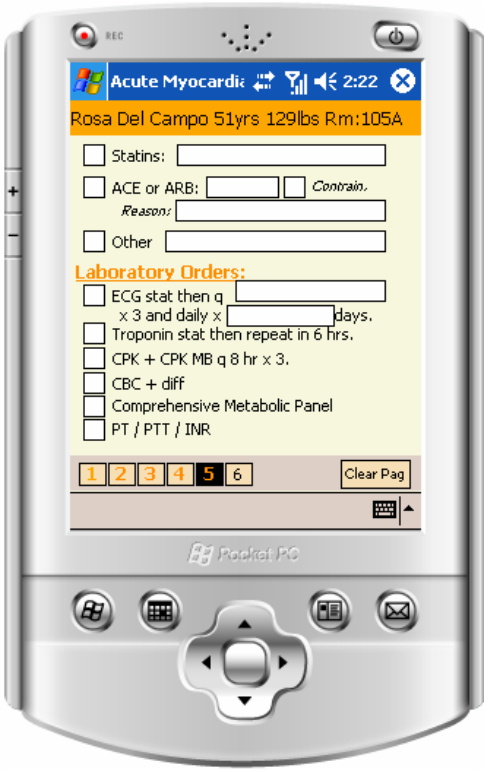

Figure B.5 Acute Myocardial Infarction Interface (page 5)

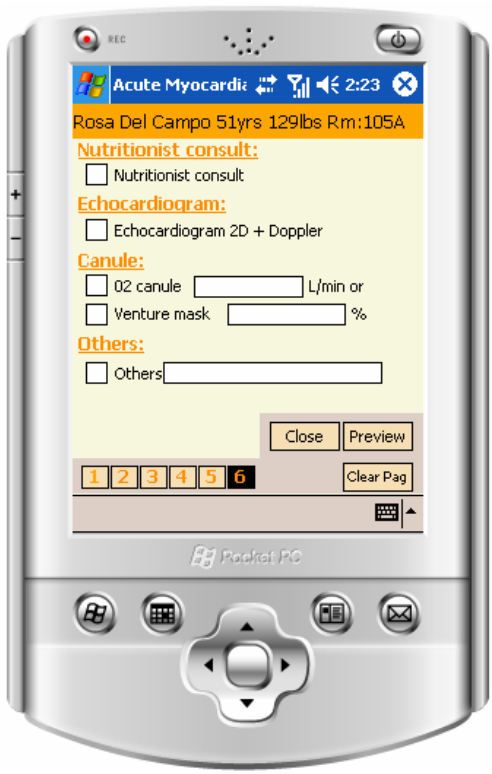

Figure B.6 Acute Myocardial Infarction Interface (page 6)

APPENDIX C

User's Characteristics

1. **Tipo de usuarios.** Existen dos tipos de usuarios:
   a) Médico residente.
   b) Médico especialista.

2. **Número de usuarios.** Se tiene aproximadamente 100 usuarios, entre médicos residentes y médicos especialistas.

3. **Conocimiento y destreza del usuario en computación.** Los usuarios cuentan con amplios conocimientos y destreza en el manejo de computadoras, ya que su formación les ha permitido tener una interacción directa y familiarizarse con las computadoras. La institución esta planeando crear un espacio de acceso al uso de estos medios de computo, con el fin que los médicos tanto especialistas y residentes tengan facilidades de adiestramiento en su uso.

4. **Conocimiento y destreza del usuario en el dominio de la tarea.** Los usuarios cuentan con amplios conocimientos y destrezas en la realización de órdenes médicas iniciales como visitas al paciente.

5. **Hábitos de trabajo del usuario al realizar la tarea.** El hábito de trabajo del usuario es realizar las órdenes médicas iniciales al momento de ingresar el paciente. Asimismo se tiene el hábito de realizar visitas a cada uno de los pacientes de acuerdo a lo programado, donde se generan las notas de progreso y nuevas órdenes médicas de ser necesarias.

APPENDIX D

Task Analysis

1. **Objetivos**

   a) **Objetivo general**

   Realizar una tarea médica en el Centro Cardiovascular de Puerto Rico y del Caribe.

   b) **Objetivos específicos**

   - ❖ Realizar una orden medica inicial al momento del ingreso del paciente.
   - ❖ Realizar visita médica al paciente, generando una nota de progreso y una nueva orden médica de ser necesaria.

2. **Procedimientos para realizar la tarea**

   Los pasos para generar la tarea médica se puede resumir en:

   a) **Pasos para lograr el objetivo**

   <u>Realizar orden médica inicial</u>

   - ❖ Determinar los datos generales del paciente:
     - Nombre completo
     - Edad
     - Peso
     - Sexo

- ❖ Determinar nombre del médico.
- ❖ Observar los signos vitales del paciente.
  - Revisar temperatura
  - Revisar presión.
  - Revisar ritmo cardiaco (pulso).
  - Revisar ritmo respiratorio.
- ❖ Determinar el diagnóstico del paciente.
- ❖ Determinar el número de piso en el que ha sido admitido el paciente.
- ❖ Determinar las alergias a medicamentos del paciente.
- ❖ Determinar indicaciones varias para el paciente
  - Ordenar pruebas de laboratorio, por ejemplo: CBC con diferencial, Lipid profile.
  - Ordenar exámenes, por ejemplo: Placa de torax.
  - Determinar medicamentos a suministrar al paciente.
  - Determinar el tipo de dieta para el paciente.
  - Determinar condiciones varias, por ejemplo: Descanso absoluto en cama, monitoreo cardíaco continuo.

Realizar visita médica al paciente

- ❖ Determinar la evaluación subjetiva del paciente.
  - Preguntar al paciente acerca de su estado.
  - Preguntar al paciente si tomo algún medicamento.

- ❖ Determinar la evaluación objetiva del paciente.
  - Repasar la lista de problemas, observando las fechas en que se manifestó y se resolvió cada problema.
  - Examinar los resultados de laboratorio.
  - Repasar kardex de las enfermedades (lista activa de medicamentos).
    - Observar información de los medicamentos suministrados.
    - Observar dosis de los medicamentos suministrados.
  - Revisar las notas de progreso previas.
  - Observar valores de pánico.
  - Observar vitales del paciente
    - Revisar temperatura.
    - Revisar presión
    - Revisar ritmo cardiaco (pulso).
    - Revisar ritmo respiratorio.
- ❖ Determinar el diagnóstico del paciente.
- ❖ Determinar el plan para el paciente.
  - Escribir una nueva nota de progreso.
  - Escribir una nueva orden medica si es necesario.

b) Interrupciones en la tarea

Las tareas médicas de realizar una orden médica inicial y visita médica al paciente, son realizadas sin interrupciones, en un mismo intervalo de tiempo.

c) Importancia de la realización de la tarea

Es de importancia que al momento de realizar las visitas el medico debe de tener en cuenta la información de las notas de progreso previas, como los medicamentos suministrados, puesto que podría causar daños en el paciente.

d) Tiempo y momento que toma la realización de la tarea

La cantidad de tiempo para realizar las tareas depende del diagnostico preliminar o la complejidad del problema de salud con la cual el paciente ha ingresado, asimismo el tiempo puede depender del tratamiento que se le esta realizando.

Las órdenes médicas iniciales pueden ser hechas en el momento de llegada del paciente sin restricción de horario. En caso en que el paciente se encuentre internado, las visitas médicas serán realizadas cada cierto tiempo, quizás a diario dependiendo de la complejidad del problema.

e) Resultado y reporte una vez lograda la tarea

El resultado y reporte de la orden médica inicial se encuentra en el formato de Órdenes Inicial de Admisión, en caso de las visitas al paciente, se tiene el formato de Notas de Progreso y Ordenes del Médico, para cualquier consulta por parte de los médicos especialistas o residentes, enfermeras y como un histórico del paciente.

f) Posibles errores en la realización de la tarea

Al dar la medicación al paciente se le puede causar reacciones adversas si no se considera la interacción de los medicamentos suministrados.

Se le pude causar daños al paciente al darle una medicación sin tomar en cuenta las alergias a medicamentos que éste pueda tener.

Si no se observa bien la información histórica del paciente, por ejemplo la que se encuentra en las notas de progreso previas, la lista de problemas, kardex de las enfermeras, se pude llegar a un diagnostico errado en la visita actual al paciente.

g) Formato de requerimientos en la realización de la tarea

Las órdenes médica inicial de la Unidad Intensivo Cardiovascular, es el procedimiento que debe realizar el médico en el momento de atender un paciente que va ser internado en la clínica.

A continuación se da una breve descripción que permite entender la información que se encuentra ahí almacenada.

Datos Esenciales:

Nombre del paciente, piso y habitación asignada, número de hospitalización, de ingreso o de orden, medico asignado, alergias a medicamentos, tipo de dieta, diagnostico, edad, peso, sexo.

Procedimiento:

1. Remisión a la UCI (unidad de cuidados intensivos), si es el caso.
2. Especificación de monitoreos.
3. Detalles si el paciente necesita una posición particular a la hora de dormir.
4. Realización de exámenes como son los EKG (Electrocardiogramas), signos vitales, toma de placas de tórax o radiografías, etc.
5. Especificación de suministros como son el oxigeno y la dosis de los medicamentos que deben ser suministrados.
6. La dieta que debe ser suministrada al paciente (Nutricionistas).
7. Las pruebas de laboratorio que se le deben efectuar al paciente (Bacteriólogos).

También dentro de las órdenes médicas se encuentran detallados ítems que permiten agrupar los procedimientos por categorías homogéneas, como son:

- Casos de bradicardia.
- Casos de bloqueo atrioventricular de segundo grado.
- Complejos ventriculares en caso de infarto agudo al miocardio.
- Fibrilación ventricular.
- Disociación electromecánica.
- Asistolia.
- Taquicardia Supraventricular paroxistia (PSVT).
- Taquicardia ventricular.
- Cardioversión

Para cada uno de los anteriores ítems se encuentra detallado los equipos que se necesitan para monitorear y/o someter al paciente, junto con los medicamentos que se le deben suministrar, los exámenes y pruebas de laboratorio necesarios.

Cada uno de los procedimientos tiene sus respectivos resultados y serán anexados a la historia clínica del paciente.

h) Visita médica al paciente

Durante la visita al paciente, la cual se realiza en el cuarto de hospitalización asignado al mismo, se determina el plan del paciente; para lo cual se escribe una nota de progreso y una nueva orden médica de ser necesario. Se puede ver en el Anexo 2 el formato de la nota de progreso; en el caso del nuevo formato de la orden médica, este es similar a la orden médica inicial.

Los médicos requieren interactuar con otros colegas para determinar el mejor procedimiento para tratar al paciente y con las enfermeras para el apoyo en los procedimientos que se van a llevar a cabo.

APPENDIX E

User Interview

A: Entrevistador

B: Entrevistado

1. <u>Entrevista a la persona encargada del área del laboratorio clínico</u>:

A: Actualmente como se llevan a cabo el procedimiento de las tomas de las muestras médicas?

B: Las muestra médicas son ingresadas al sistema por las enfermeras encargadas y luego son enviadas al laboratorio clínico.

A: Cual es el nombre del sistema que actualmente se esta utilizando?

B: El sistema se llama Zerner, cuya finalidad imprime en sitckers la información que necesita las personas encargadas del laboratorio para realizar dicha toma de la muestra.

A: Que información se encuentra consignada en los stickers?

B: Bueno, allí encontramos por obvias razones la información básica como son: el nombre del paciente, fecha/hora de la toma, numero del registro y además se encuentra el nombre de la prueba que se va a realizar, la codificación en barras, donde se encuentra el nombre

del medico, campo en blanco para el nombre de la enfermera, color del tubo, procedencia del paciente y el número del specimen.

A: Como es el proceso de comunicación entre las enfermeras y las personas del laboratorio clínico.

B: Las enfermeras ingresan la información anteriormente mencionada en el sistema, imprimen el sticker y lo envían al laboratorio clínico.

A: Cuando llega el sticker por parte de las enfermeras ustedes que hacen?

B: Se lee el código de barras para identificar toda la información y que quede almacenada en el sistema.

A: Ustedes tienes levantados unos rangos o parámetros para cada una de las muestras medicas?

B: Si, cada una de las muestras medicas que se realizan tienen, primero que todo sus características de preparación antes de la misma y de igual manera para el resultado se tienen indicadores de rango que nos permiten determinar alertas e identificar cuadros de resultados con rangos de pánico, si llega a hacer el caso.

A: Este sistema tiene respaldo de la información?

B: Si, Precisamente por esta actividad, el sistema generalmente presenta inconvenientes ya que el sistema se cae muy seguido, cuando esta realizando este proceso.

2. Entrevista a la persona encargada del área de farmacia:

A: Actualmente farmacia tiene algún sistema?

B: Si, utilizamos el Zerner que tiene varios módulos no amigables y que trabajan en conjunto con las áreas del laboratorio clínico y otras dependencias de la clínica.

A: Como ocurre aquí el proceso para que a ustedes les llegue los medicamentos que deben ser administrados al paciente?

B: Nos llega físicamente el orden generada por el medico para el suministro de medicamentos. Cada una de estas ordenes tiene dos copias entonces a nosotros nos llegan las copias amarillas.

A: Entonces cuando el medico genera la orden simplemente llega a donde ustedes para que esta se despachada?

B: En realidad no, porque primero debemos aprobarla, esta aprobación consiste en verificar si ese medicamento puede ser suministrado al paciente, o si presenta alguna alergia o la cantidad de dosis es la adecuada, es decir, cuidar en todo sentido las contraindicaciones del paciente, ya que como se lleva un historial de los pacientes que permite hacer seguimiento de todos los suministros que se le hayan efectuado.

A: Y entonces las enfermeras como administran los medicamentos que se les están suministrando en ese momento al paciente y de manera efectiva?

B: Las enfermeras simplemente van llevando este control en el Kardex.

A: Como es que se llama el sistema que utilizan actualmente??

B: Kean.

A: Y después de ingresado y aprobado los medicamentos que se le van a suministrar al paciente cual es el paso a seguir?

B: Bueno de ahí, se imprime el MARS que indica los medicamentos que deben ser suministrados por parte de las enfermeras hacia cada uno de los pacientes.

A: Cuales son los tipos de ordenes de medicamentos que se suministran?

B: Bueno se tiene el Med, IV, Piggy Back, TPN

3. Entrevista con el área de las órdenes medicas de manera física:

A: Cuando se efectúa el diagnostico del paciente?

B: Este diagnostico se realiza en el momento que el paciente as admitido, es decir, al momento de ingresar a la clínica.

A: En algún momento se cambia este diagnostico? En que circunstancias?

B: Si, puede llegar a cambiar el diagnostico es el caso cuando ingresa el paciente con un cuadro clínico y después se van encontrando ciertas anomalías en otra área.

A: Que son las notas de progreso?

B: Es allí donde se le va realizando el seguimiento al comportamiento del paciente, si llega a existir el caso, como se menciono anteriormente que cambia el diagnostico inicial del paciente, entonces en las notas de progreso se escribe cada unas de las condiciones por las cuales se realizo tal cambio permitiendo conocer el progreso del paciente.

A: Estas notas que metodología desarrollan?

B: Llevan a cabo lo que denominamos SOAP que quiere decir: Evaluación subjetiva (Subjective Evaluation), Evaluación Objetiva (Objective Evaluation), Evaluación (Assesement) y finalmente el Plan.

A: Cuando un paciente llega a la clínica este debe cumplir con una rutina para su admisión, este procedimiento como es elaborado?

B: Estos procedimientos se encuentran regidos por unos protocolos que se han levantado, y en el cual el medico encargado debe realizar, lo que comúnmente se dice chequeos de rutina.

A: Que contienen las ordenes de admisión?

B: Esta el nombre del paciente, la habitación a donde será hospitalizado, el numero de la orden, el medico que lo atiende, si tiene alguna contraindicación a algún medicamento, la dieta que se le debe suministrar, la edad, el peso, el sexo y otras como son los signos vitales: pulso, presión arterial, respiración, temperatura.

A: Cuando el medico realiza las visitas a sus pacientes, cual es la información que necesita tener a la mano?

B: Necesita tener a la mano la información que se ha llevado como la evaluación del paciente, la lista de problemas o complicaciones presentados a lo largo de la estancia del paciente, de igual manera revisa el kardex de la enfermera para revisar los medicamentos que se encuentran tomando el paciente y que por supuesto farmacia dio su aprobación.

Finalmente se necesitan todas las pruebas de laboratorio junto con las notas de progreso anteriores si es el caso para que sirva de apoyo a la nueva nota que se vaya a realizar y si esto repercuta a una nueva orden que sea fácil de interpretar del porque se realizo.

A: Que pasa con la lista de problemas?

B: Esta en muchas ocasiones es omitida y no se encuentra consolidad en ninguna parte por ende se debe ir a revisar cual fue la evaluación inicial del paciente tanto física como el historial de información y junto a esto se debe chequear la evaluación diaria que se realiza en las visitas y que son especificadas en las notas de progreso.

A: Que pasa con la lista de problemas?

B: Con la lista de problemas se deberían almacenar en otro formato, pero nos encontramos con el caso peculiar que van junto a las notas de progreso, y por ende para identificarlas se debe realizar una búsqueda dentro de este documento, que permita conocer las anomalías que ha presentado el paciente.

A: Como cada una de las visitas que realiza el medico es muy importante y todo lo que encuentra el medico se registra en las notas de progreso, una buena nota de progreso debe ser elaborada y que información debe tener almacenada?

B: Se debe tener el problema que se encontró de tal manera que estas se vayan ir almacenando como una lista, especificando la fecha y la evolución del problema que se encontró, la lista de medicamentos por si en dado caso el nuevo problema repercuto en nuevas dosis, y resaltar aquellos valores que entre en el rango como pánicos.

Por otra parte las vitales son muy importantes como son: la presión, temperatura, ritmos cardiacos y respiratorios.

A: Además de las ordenes medicas, el medico con que mas resultados cuenta para el seguimiento y evolución en la recuperación del paciente?

B: Primeramente se realiza un estudio del diagnostico, y si este corresponde al motivo por el cual ingreso inicialmente el paciente se continua con el procedimiento que corresponde, en caso contrario se realizan anotaciones en las notaciones de progreso, junto a estas notas también encontramos los resultados de las pruebas de laboratorio, los medicamentos y el tipo de dieta que se le debe brindar al paciente.

APPENDIX F

Hierarchical Task Analysis Diagrams

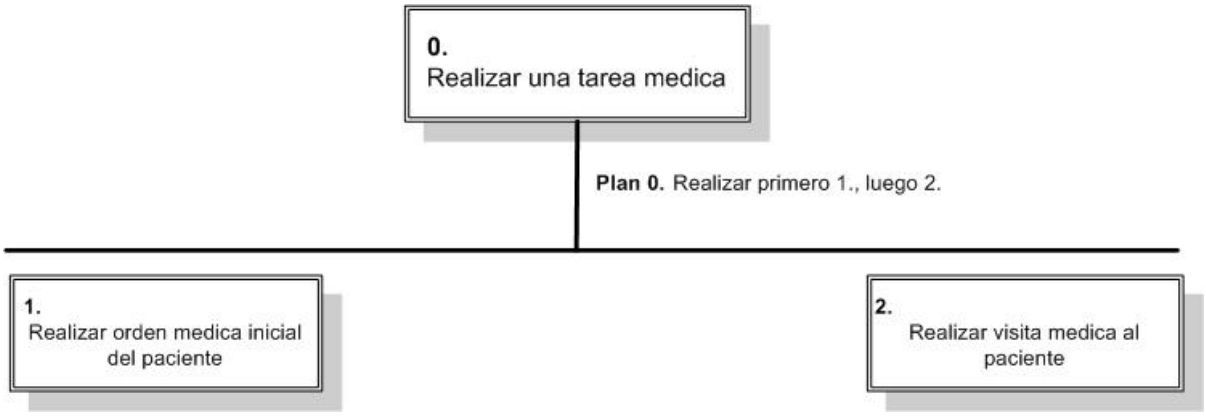

Figure F.1 HTA Level 0.

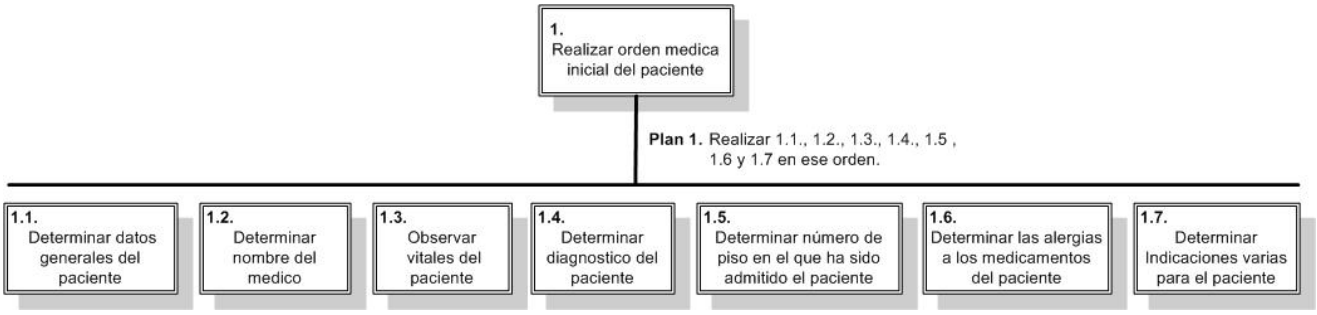

Figure F.2 HTA Level 1.

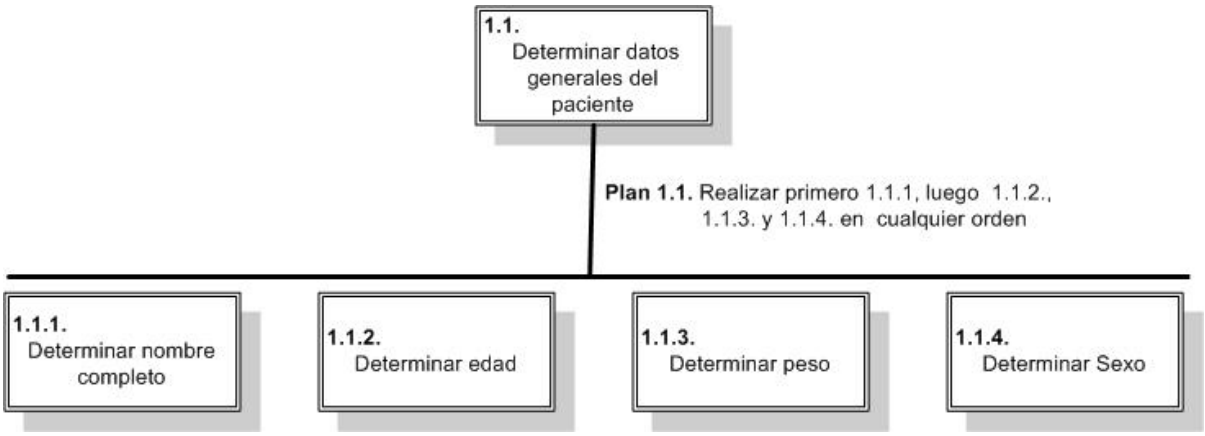

Figure F.3 HTA Level 1.1.

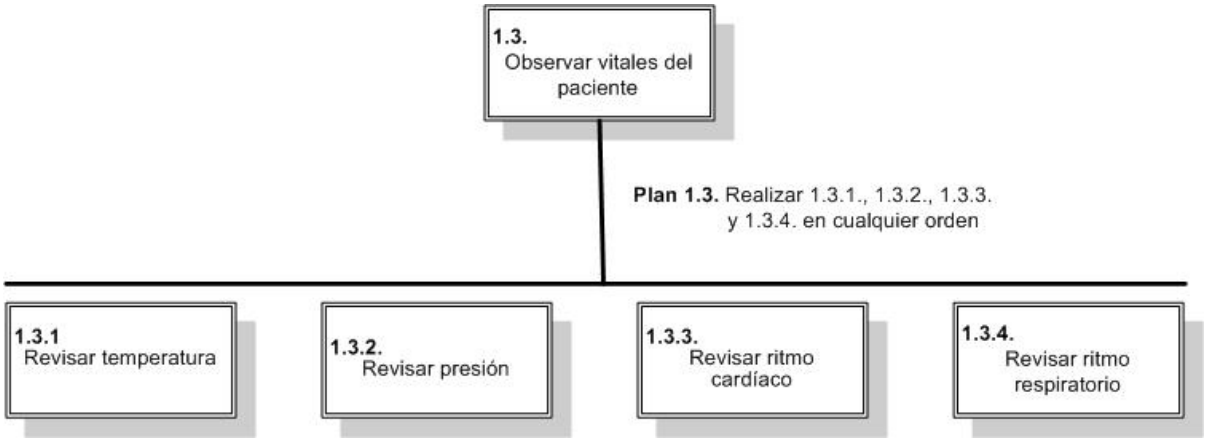

Figure F.4 HTA Level 1.3.

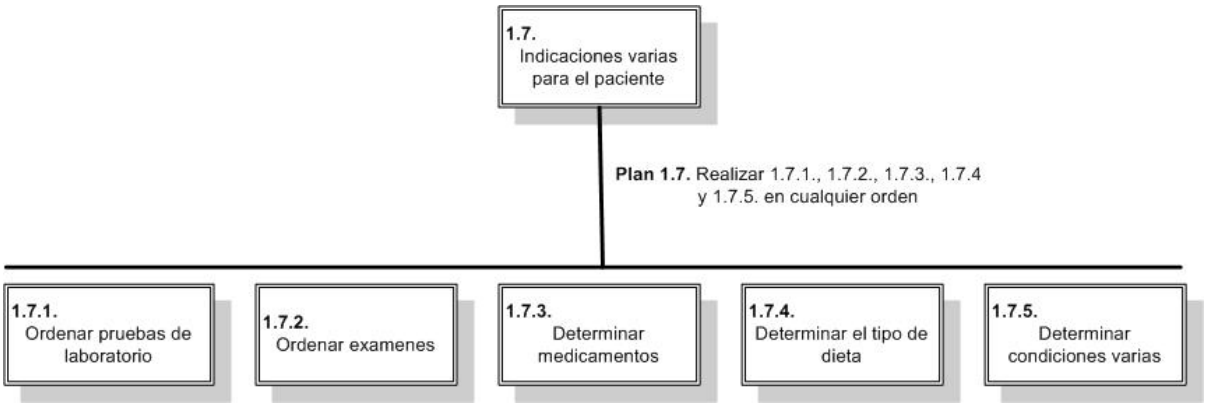

Figure F.5 HTA Level 1.7.

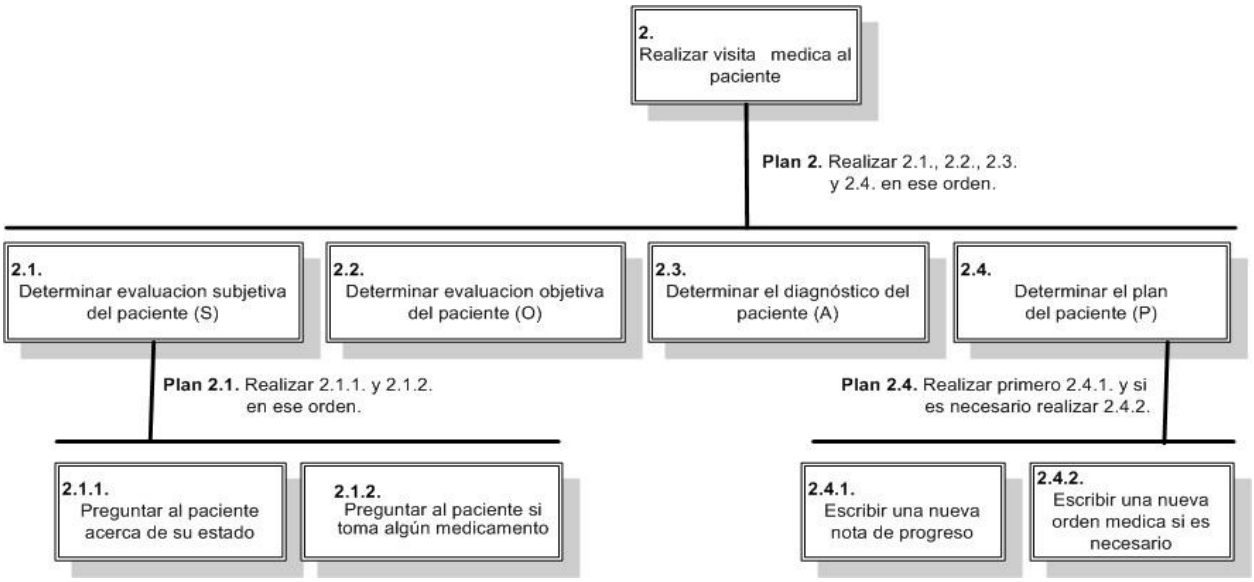

Figure F.6 HTA Level 2.

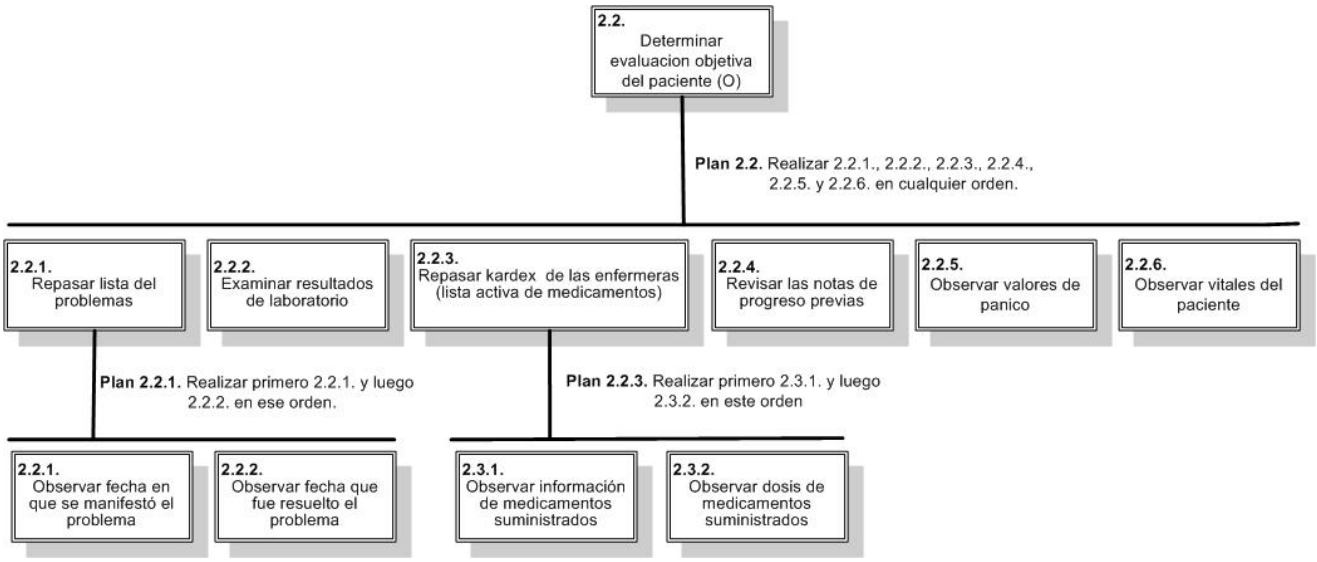

Figure F.7 HTA Level 2.2.

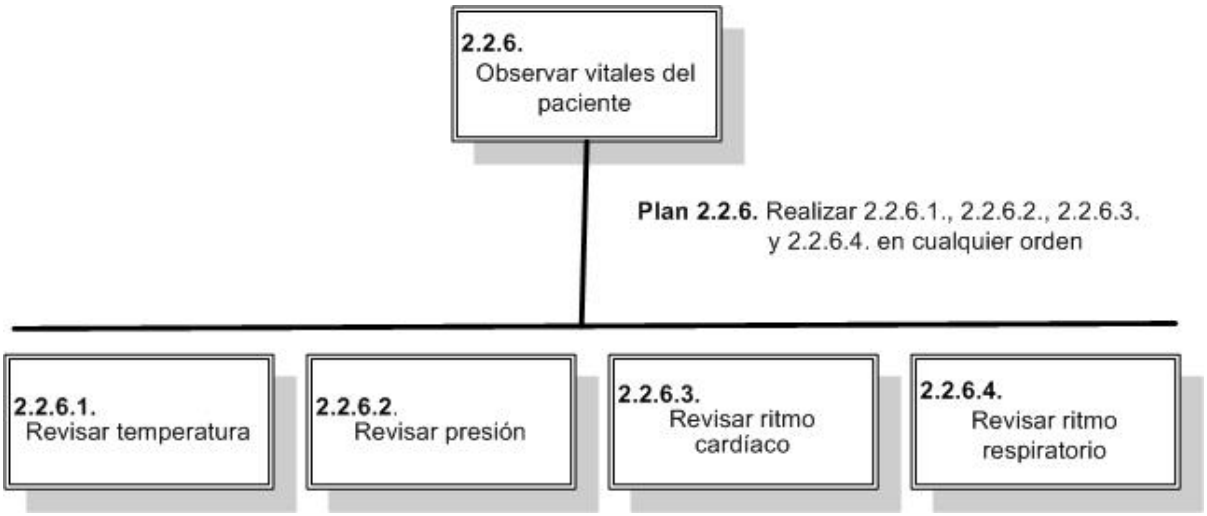

Figure F.8 HTA Level 2.2.6.

APPENDIX G

Orientation to the User

Saludos, mi nombre es Nadia Olarte Enciso. Voy a trabajar con ustedes en la sesión de hoy. Voy a explicar la razón por la que le he pedido que estuviera aquí hoy.

Vamos a realizar una evaluación heurística a un sistema de récord médico electrónico en computadoras portátiles como “estas”. El objetivo de esta evaluación es identificar problemas de usabilidad y su severidad cuando el sistema interactúa con el usuario. Para poder hacer esto, necesito su ayuda. Usted realizará algunas tareas típicas con el sistema de récord médico sin preocuparse por los resultados. Ésta es una prueba de los sistemas electrónicos, no de usted. Los sistemas todavía están en una versión prototipo, por lo que puede ser que no trabajen como usted espera. Usted puede hacer preguntas en cualquier momento, pero puede que no se las contestemos, puesto que éste es un estudio a los sistemas electrónicos y necesitamos ver cómo se desempeñan.

Utilizaré un código para referirme a usted en el análisis de los problemas de usabilidad de manera que su participación sea anónima.

¿Tiene alguna pregunta?

Entonces, comencemos con la sesión.

APPENDIX H

User's Consent Form

Id: _____

Como parte de un proyecto de investigación, estoy realizando una evaluación heurística a un sistema de record médico electrónico, el cual se encuentra en un Asistente Personal Digital (PDA por sus siglas en inglés). El propósito de la evaluación heurística es identificar los problemas de usabilidad y su severidad cuando el sistema interactúa con el usuario.

A las personas que participen en la evaluación se les solicita que realicen una serie de tareas en el sistema electrónico. Para posteriormente indicar los problemas de usabilidad encontrados y el grado de severidad durante su interacción con los sistemas electrónicos. La identidad de los(las) participantes será protegida y solamente los/las investigadores/as tendrán acceso a la información recopilada.

Yo, _____, voluntariamente consiento a participar en el estudio antes descrito. Se me ha orientado sobre el propósito y procedimiento del mismo. Entiendo que no serán revelados mis datos personales y que los resultados de la evaluación pueden ser utilizados como parte de un proyecto de maestría. Asimismo, entiendo que puedo abandonar este estudio en el momento que así lo desee y que se garantiza mi confidencialidad.

_____ _____

Firma del Participante Fecha

APPENDIX I

Tasks for Heuristic Evaluation

1. Indique en voz alta los nombres de los(as) pacientes a los(las) que se les tiene que atender una consulta.
2. Acceda al record de la paciente Rosa del Campo
3. Indique en voz alta la edad y el peso de la paciente.
4. Indique en voz alta la última temperatura tomada a la paciente.
5. Realice las siguientes órdenes médicas:
   - Medicamento: Lasix, 40 mg, IV, q12h, start today until 21 of the month.
   - Laboratorio: CBC of "Blood".
   - Laboratorio: PT control of "Coagulation Hematology".
   - Otras órdenes: Input & output
   - Ordenes Generales: Vital signs every 2 hours.
   - Otras órdenes: Care of tube drainage of chest.
   - Ordenes Generales: Low cholesterol diet.
   - Consulta: Consult to the physician Bartolo Colón of Endocrinology for recommendations in the management of hypothyroidism.
   - Remove the laboratory order of PT Control of Coagulation Hematology.

6. Guarde todas las órdenes médicas realizadas hasta el momento.
7. Señale todos los medicamentos que se le han sido suministrados a la paciente.
8. Busque la nota de consulta de la paciente Rosa del Campo hecha por el Dr. Luis Rivera y leala en voz alta.
9. Escriba la siguiente nota de progreso de la paciente Rosa del Campo: “Pt presents irregular HR and CHF caused by HTN”.

APPENDIX J

List of Usability Problems Form

Id: _____

1. _____

   (Error sin mucha consecuencia) 1 2 3 4 5 (Error catastrófico)

2. _____

   (Error sin mucha consecuencia) 1 2 3 4 5 (Error catastrófico)

3. _____

   (Error sin mucha consecuencia) 1 2 3 4 5 (Error catastrófico)

4. _____

   (Error sin mucha consecuencia) 1 2 3 4 5 (Error catastrófico)

5. _____

   (Error sin mucha consecuencia) 1 2 3 4 5 (Error catastrófico)

6. _____

   (Error sin mucha consecuencia) 1 2 3 4 5 (Error catastrófico)

7. _____

   (Error sin mucha consecuencia) 1 2 3 4 5 (Error catastrófico)

8. _____

   (Error sin mucha consecuencia) 1 2 3 4 5 (Error catastrófico)