

DEVELOPMENT OF A SYSTEM TO SUPPORT THE CLINICAL TASKS OF PHYSICIANS WITH PCS AND TABLET PCS

by

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ABSTRACT

This work describes the development of a system to support physicians' clinical tasks by means of personal computers and Tablet PCs. The system facilitates the physicians review of patients' vital information such as the patient's problem list, laboratories results and diagnostic studies, vital signs, balance of fluids, nurse notes, progress notes, administration of medications, and medical orders. The system also provides interfaces for physicians to deal with clinical documentation such as problem lists, progress notes, health history, and physical exam. In addition, the system provides interfaces for physicians to generate medical orders such as: medications, laboratories, consultations, diets, restrictions, therapies and transfers. The system was subjected to a usability heuristic evaluation, which served to identify potential usability errors and to carry out the respective adjustments of the system.

RESUMEN

Este trabajo describe el desarrollo de un sistema para apoyar tareas clínicas de médicos mediante PCs y TabletPCs. El sistema facilita a los/las médicos la evaluación de información vital de pacientes como la lista de problemas de pacientes, resultados de laboratorio y estudios diagnósticos, signos vitales, balance de fluidos, notas de enfermería, notas de progreso, administración de medicamentos y órdenes médicas. El sistema también provee interfaz para facilitar la documentación clínica de problemas de salud de pacientes, notas de progreso, historial médico y examen físico. Además facilita la generación de órdenes médicas tales como medicamentos, laboratorios, estudios diagnósticos, consultas, dietas, restricciones, terapias y transferencias. El sistema fue objeto de una evaluación heurística de usabilidad la cual sirvió para identificar potenciales errores de usabilidad y realizar los respectivos ajustes al sistema.

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To my family, specially:

Mom, Dad,

Brothers, Sisters,

Nephews, Niece

and CarlosE.

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1. INTRODUCTION

In any clinical area at a hospital physicians carry out several tasks that involve handling patients medical records. One of the most important tasks they carry out is to assess the condition of their patients' health and specify their treatment, other tasks involve:

1. reviewing the medical record of each one of their patients.
2. documenting the patient's conditions
3. specifying medical orders such as: medications, laboratory tests, diagnostic studies, consults, diets, etc.

These tasks need to fulfill certain properties: speed, readiness, legibility and precision of the medical orders by the physicians, because these actions play an important role in the treatment of patients and the improvement of their health.

The use of patient's electronic record systems can help to avoid problems such as the illegibility of medical orders and patients' health documentation by physicians. This problem may induce nurses to commit errors in the transcription of medical orders into hospitals documents [Ramos05]. The lack of legibility presents a serious problem because it may end up causing medication errors that could affect the patient's health and can even cause their death.

The electronic patient record systems can minimize the errors in medications orders because they can provide clear medications names and administer ration dosage. Electronic record systems also help to minimize the problem of updating the patients' records because nurses are usually busy and overloaded. In many occasions nurses make annotations of the patient's health but those annotations "travel" with them until they can sit down to pass them to the medical records. An electronic patient record system can provide solutions for this problem through mobile alternatives such as Personal Digital Assistants (PDA) or Tablet PCs [Rodriguez03, Rodriguez04, Crespo05]. One of these alternatives, the Tablet PCs, is the focus of this work.

Having a patient's electronic record systems integrated definitively can help to minimize many of the problems presented above. This is the main motivation of the work presented in this document. It describes an application that improves physicians' clinical tasks at a hospital. The application is an evolution of various prototypes previously developed by investigators of the University of Puerto Rico at Mayaguez [Borges97, Rodriguez03, Rodriguez04, Crespo05, Perez05, Ramos05]. The system integrates re-designed versions of interfaces of medical orders [Ramos05] and nursing documentation for PC and Tablet PC platforms [Crespo05]. The application was developed following usability engineering principles to allow easy learning, minimization of navigation, minimization of errors and increased user satisfaction.

1.1 Objective

The primary objective of this project is to develop a system to support the clinical task of doctors with its patients in a hospital by means of the use of personal computers and Tablet PCs. This system will facilitate physicians reviewing their patients' records, documenting their condition and writing medical orders. The software will facilitate physician reviewing the patient's problem list, results of laboratories and diagnostic studies, vital signs, balance of fluids, nurse notes, progress notes, administration of medications, and medical orders. The system will also provide the means so that physicians can document the following: problem lists, progress notes, health history, physical exam and other notes. In addition, the system will provide facilities so that physicians can write the following medical orders: medications, laboratories, diagnostic studies, consultations, diets, restrictions, therapies, transfers and others.

1.2 Thesis Outline

Next chapter provides a literature review of previous work related to the integration of the sources information in clinical areas and usability studies of portable devices like Tablet PC with medical application. Chapter 3 provides a detail description of each interface for the Tablet PC-based medical orders and documentation application. A description of a usability evaluation based on physicians interaction with the system is presented in 4. Finally, the conclusions and future work are presented in Chapter 5.

2 PREVIOUS WORK

2.1 Systems for Handling Patient Information in Clinical Areas

There are several projects or studies related to the handling of patient's information in a hospital from the point of view of the clinical tasks of the physician. In [Taddei97] a study is described based in the handling of patient records with computers that maintain information about laboratory tests and diagnostic images like: Radiology, Echocardiogram, Nuclear Medicine, and Stress Tests, among other, with the collaboration of the department of Cardiology. This prototype used a software environment via Web with HTTP tools under a client-server configuration. The results of the study indicated that an integration of all the sources of information of the department was obtained, which allowed an interaction between cardiologists and nurses.

Another application was developed at LUMAC Department of Cardiology [Van der Velde01] to store all data regarding catheterizations, pacemaker implants and follow-up, clinical and interventional waiting lists. They compared regular notebooks, notebooks without keyboard and Siemens Simpad. The cardiologists preferred the last one, because of its small size and quick response. They concluded, that the combination between a well

designed application and a good portable device would improve the access to the critical information of cardiology about patients that are in the CCU (Coronary Care Unit).

2.2 Interaction with the Graphical Interface

In [Rodríguez02] a comparison of physicians interacting with two patient record systems is described. The systems were a text-based system and a graphical system with similar capabilities. The physicians were asked to perform tasks that required reviewing a patient record, documenting the patient's condition and specifying medical orders. The participants were residents of internal medicine. The results of the study revealed that a graphical-based interface can significantly reduce the time it takes physicians to complete typical tasks in comparison with a text-based interface. The results of the study also revealed that physicians can get more satisfaction from interacting with a graphical-based electronic patient record system than with a text-based system.

Another study compares two prototypes of user interfaces for nurses to carry out medical orders tasks [Staggers00]. One of them was based on text and the other was a graphical environment (GUI). This study was carried out in a medical center in the oriental coast of the United States and it had the participation of 98 nurses that carried out 40 tasks that were: to create, to activate, to modify and to eliminate medical records. These tasks allowed to measure and compare response times, frequency of errors and degree of

satisfaction. The study concluded that the graphical interface is considerably quicker, with less errors and a high rate of satisfaction for all the tasks carried out.

In a work carried out by D.F. Sittig et al. [Sitting99] acceptance and satisfaction of physician in conducting tasks on an electronic patient record system was studied. The sample had 75 physicians and a system denominated BICS (Brigham and Women's Integrated Computing System) that was be the work material for the test. The evaluation method was by means of questionnaires that allowed measuring the satisfaction in the interaction of the user with the system. The results indicate that the level of acceptance and the medical personnel's satisfaction depends a great deal on the design of the interface and the disposition of the tools.

2.3 Interaction with Devices and Usability Studies about Health Information Systems.

In [Rodriguez04] two versions (PDA and laptop) of an application to access an electronic patient record system were compared in terms of the efficiency and satisfaction achieved by physicians while conducting typical tasks, such as reading vital signs, handling medical orders, reading lab results and writing notes. Twenty internal medicine resident physicians from a teaching hospital in the Boston metropolitan area participated in the study.

The results of this studied indicated a relative small advantage of the PDA to complete all the tasks. However, the level of satisfaction was in general higher for the Laptop. On the other hand, the physicians are significantly faster performing tasks that require text entry and reading on a Laptop than on a PDA. As pointed out in [Rodriguez04] this finding suggests that user interfaces on the PDA should be designed in such a way that text entry is minimized.

Another study compares the interaction of the nurses with Tablet PC and PDA using a nursing documentation application [Rodriguez07]. This application allowed nurses to perform typical nursing tasks such as viewing and entering vital signs, acknowledging pending medications, viewing and documenting intake/output of fluids and reading and writing notes. Twenty staff nurses were asked to complete 13 tasks. The results indicate that: (1) nurses are as fast on the PDA as on the Tablet PC, (2) nurses were able to complete the majority of the tasks, (3) completion time correlates with nurses' age, (4) nurses preferred the PDA version over the Tablet PC version.

The study also revealed that the two versions of the nursing documentation systems are very easy to learn and nurses required minimal training to learn how to use them. In addition the study revealed that in general nurses were equally satisfied with both versions with the exception of the use of the stylus, weight and portability of the systems. In these three aspects nurses were significantly more satisfied with the PDA system than with the

TabletPC system. The study concluded that the small screen size and display resolution of the PDAs are not factors that limit nurses' performance and satisfaction in comparison to Tablet PCs.

2.4 Alerts and Reminders Systems.

With the collaboration of the Weill Cornell Medical Center in New York a study was conducted where several elements were analyzed that allowed, in the clinical environment, to develop a methodology that supported all the procedures and the tasks that are pending [Oppenheim00]. The method used for indicating pending procedures was to assign alerts to each procedure. For example when a radiology test is ordered to a woman, it should be kept in mind if this patient is pregnant and if this is the case, the system should inform that the procedure should not be performed because this factor is part of the restrictions of this task. This is appropriate in general physicians' environment, but probably in environments of specialty like this case, obstetric or gynecological it is not so applicable. This system of alerts is administered by means of a database of knowledge, which possesses the procedures, parameters or established ranges of conditions or normal behaviors of each procedure requested in the hospital.

On the other hand, these alerts also require maintenance and in many occasions they will have to be upgraded, as it happens in case of a change in the clinical knowledge. For example, we have the case of an alarm to remember dose adjustments in the medications of a patient with hypoglycemia or diabetes.

The result of this work was to design a strategy that carried out multi-functional clinical alerts, which settled down under the following conditions: (1) Each alarm will be visualized by the user in charge to this task, (2) The alarms had reading/writing privileges, (3) The alarms had visualization parameters like color and shape, (4) The critical alarms will be shown by means of dialog boxes at the first moment, when entering to the system.

The thesis work of Carlos Pérez [Perez05] presents a usability study of a system of alerts and reminders for nurses in a hospital clinical area. The main module of this system shows a list of patients with a visual element that indicate pending tasks or alerts conditions of the patients. The pending tasks or alerts are represented with colored shapes (green circle, yellow mid size oval and red large size oval). The green circle indicates a task that needs to be performed in the near future. A yellow mid size oval indicates a task that is approaching its due time. A red large oval indicates a task that has expired its due time.

The results of this study indicated that age was a key characteristic in the participants' ability to perform the tasks; younger nurses demonstrated better performance than older nurses. In general, the nurses learned how to use the system very easily even though they did not have experience with electronic records nor with table PCs.

3 SYSTEM DESCRIPTION

3.1 Introduction

In this chapter, we first describe the paper-based record system used to develop the electronic version for a Windows platform (desktop and Tablet PC). The paper-based system was part of the record system of a metropolitan hospital serving cardiovascular patients. This paper-based record system was use as the basis for the development of the electronic version presented in this chapter. This version was developed for a Tablet PC but can run as well on a Windows desktop platform. This system integrates previous work developed at UPRM by master students Jaime Ramos [Ramos05], Gilberto Crespo [Crespo05] and Carlos Pérez [Perez05].

The objective of this project was achieved through various phases (See figures 3.1). An explanation of each phase follows:

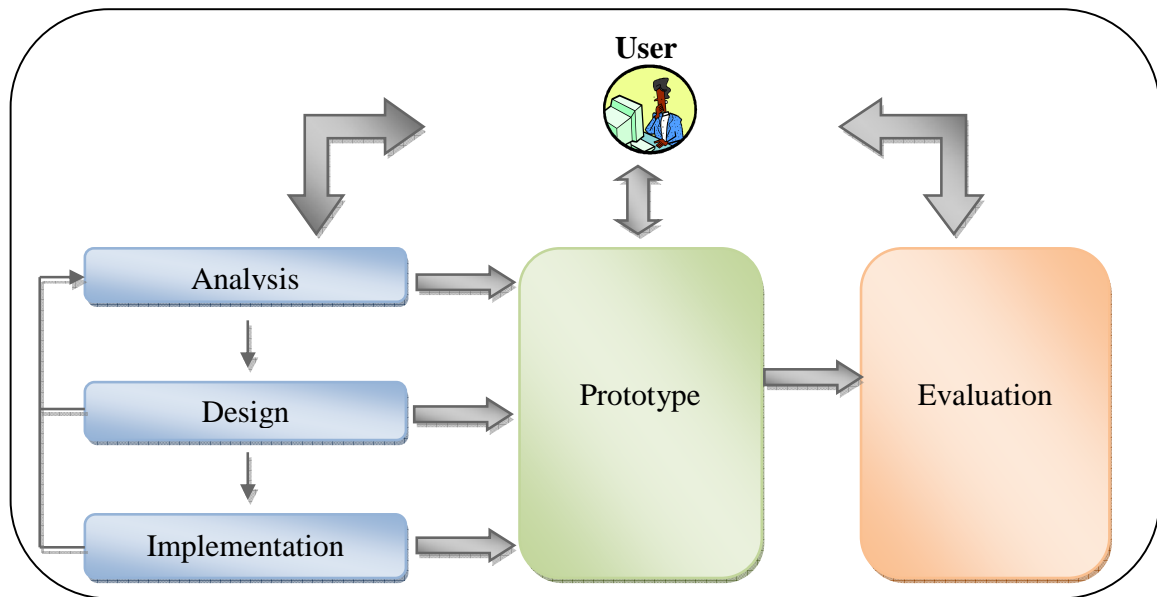


Figure 3.1 Development Process Model

Analysis phase:

This phase involved meetings with physicians to get information to establish the requirements of the system that addressed their needs when performing clinical tasks.

Design phase:

By means of meetings with the research group, some low fidelity prototypes (paper prototypes) of the user interfaces were developed taking into account the needs of the user and usability engineering principles. The prototypes were evaluated by the research team usually resulting in recommendations for additions and modifications.

Implementation phase:

The next step was the implementation of the system in a high fidelity prototype based on the low fidelity prototypes. The implementation involved the implementation of the interface layout and functionality as well as modification to the patient records database. The prototypes were presented to physicians for their recommendations, comments and

identification of missing functionality. The physicians' recommendations were taken into account resulting in modifications to the prototypes.

Evaluation phase:

With the collaboration of a group of evaluators, a heuristic evaluation was carried out. This evaluation resulted in the identification of potential usability errors. The research team evaluated the errors identified and corrections were made to the prototypes to fix the potential errors.

3.2 Paper-based Prototype

This section describes the paper forms used by physicians to write medical orders and document the health of the patients as well as forms used by nurses to transcribe physicians' orders. These forms are actual forms used in two cardiovascular hospitals in Puerto Rico.

3.2.1 Physician's Orders Form

The physician's orders form is shown in figure A-1 of the Appendix A. It contains a header divided in two parts. In the left section the user writes diagnosis and allergies to medications, in the right section the user enters patient's name, room number and record number. Below there are four columns: date & time, description, date & time, and nurse's initials. For each order the physician enters the date and time on the left column and writes the order on the space provided on the column to the right. Nurses must acknowledge each

order by entering the date and time on the column to the right of the order and writing their initials beside it.

3.2.2 X-Ray Orders Form

The X-Ray orders form is shown in figure A-2 of the Appendix A. This form has a header whose purpose is to indicate the study type and room number. The section below the header provides spaces for providing information about the patient, type of exam requested, physician's name and signature, diagnosis and patient's signature. A blank space is provided below for the radiologist to write the result of the study.

3.2.3 Consult Order Form

The Consult Orders form is shown in figure A-3 of the Appendix A. This form provides a blank header to enter patient's name, weight, height, age and medical record number. Below the header there is a space for indicating the name of the physician being consulted and options for indicating the type of consultation and the date and time when it is requested. This is followed by a space provided indicate the reason for the consult, and the name and signature of the physician requesting the consult. Below follows fields for indications on how to proceed with the consult. Next is a blank space for the consulted physician to provide his/her observations. Finally, there are spaces at the bottom for the consulting physician to sign and provide date of the consult.

3.2.4 Restraint Orders Forms

The Restraint Orders form is shown in figure A-4 of the Appendix A. This form has a header with the patient's name, weight, height and age. Below the header there are options for indicating what to do before restraining, the area to be restraint and the reason for restraining. This is followed by spaces for indicating the date and time ordered the physician's signature and license number, and information about the nurse if the order was taken by phone. A table is provided at the bottom with options indicated at the top row and space for entering the required information in case the physician needs to reorder the restraint.

3.2.5 Physician's Notes Form

The Physicians Notes form is shown in figure A-5 of the Appendix A. It is just a form with two columns. In the first column the physician enters the date and then the note on the second column.

3.2.6 Patient History Form

The Patient History form is shown in figure A-6 of the Appendix A. At the top of the first page (See figure a-6a) there are spaces for indicating the patient's name, record number, gender and age. Below there are blank spaces to enter the chief complaint, history of present illness and past history. This is followed by a table with three columns. In the first column

there are listed various diseases names, in the second and third column there are options for indicating if the patient had the disease (Yes) or not (No), and a field to add comments. At the bottom there are options for specifying the patient's social history, family history and diseases in the family.

The second page (See figure A-6b) is for documenting the review of systems. It provides a table with four columns. The first column indicates the body system or organ followed by a column for indicating a positive (Yes) or negative (No) finding. The last column provides a blank space for writing comments if there is a positive finding for a particular item. At the bottom there is a blank area for describing any functional risk criteria.

3.2.7 Physical Examination Form

The Physical Exam form is shown in figure A-7 of the Appendix A. In the header, there are fields for indicating the patient's name, age, weight, height and vital signs. Below the header there is a table with three columns. The first column indicates the category of the organ or body system to be examined. The second column provides check boxes for specifying conditions of the different organs and body systems being evaluated. The third column provides a space for entering observations of each of the organs or body systems examined. At the bottom of the second page of the form are blank spaces for entering a diagnostic impression, specifying the treatment plan, entering the date and time of the exam and the physician's signature.

3.3 Table PC Prototype

This section describes the Tablet PC interfaces of the patient record system. This version was developed in JAVA using the Eclipse user interface development environment. The patients' records are store in a database system administered with MS SQLServer 2000. Access of the patient records is accomplished via wireless communication through IEEE 802.b standard protocol.

The design and development of the user interfaces was guided by the usability engineering attributes of learnability, efficiency, errors and satisfaction. Learnability is a usability attribute that indicates the ability of users to learn to use an application and achieve productive work. Efficiency is the usability attribute that indicates the level of productivity that can be achieved with a user interface. Error is the usability attribute that indicates the potential of the user interface to get the users in erroneous situations. Satisfaction is the usability attribute that indicates how many the users like using an application.

3.3.1 Patient List Interface

The patient list window shown in figure 3.2 is the interface that appears after a user logs into to the system. The list displayed is the list of the physician's patients currently hospitalized. The list indicates the patient's name and room number. A patient can be selected from the list by double clicking on its name.

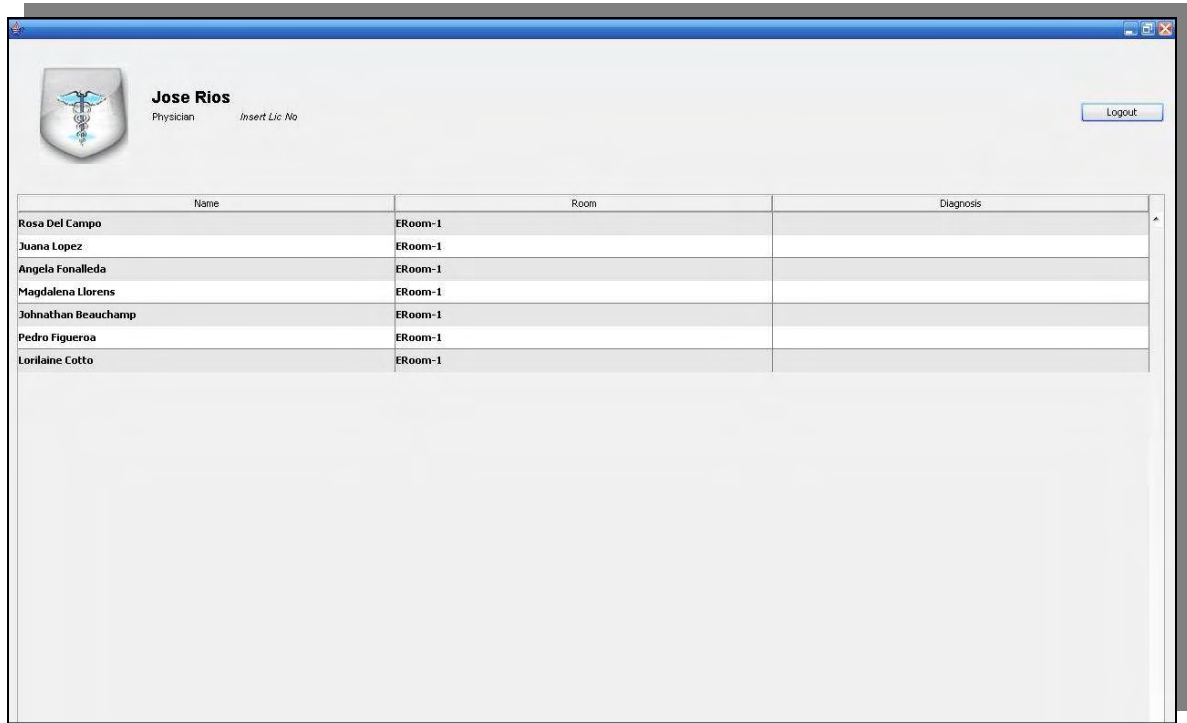


Figure 3.2 Patient List Interface

3.3.2 Patient's Summary Interface

Once a patient is selected from the patients list window the window shown in figure 3.3 is displayed. This window provides the physician an overview of some relevant aspects of the patient's condition. It provides a list of current medications, active problems list, most recent vital signs and laboratories or diagnostic studies. In addition the window provides relevant patient information at the top left side. The patient's summary is one of several tabs that allow physicians to document the patients' condition and specify medical orders. The user can move from tab to tab by clicking on the title of the respective tab on the tab bar.

Physician's Orders

File Edit Help

Rosa del Campo
 Gender: Female Age: 46 yrs Weight: 129 lb Height: 5 in
 ERoom: 1 Account No: 3 Record No: 3

Pericillin Help Logout

Summary Orders Notes Patient History Physical Exam

MEDICATION

Name	Details
Protonix	Start Date: 2007-03-29 / Dosis: 40 mg / Route: IV / Frequency: d
Toradol	Start Date: 2007-03-29 / Dosis: 30 mg / Route: IV / Frequency: qd
Sulfa Ds	Start Date: 2007-03-29 / Dosis: 1 lb / Route: PO / Frequency: q4hr
Solu-Medrol	Start Date: 2007-03-29 / Dosis: 40 mg / Route: IV / Frequency: q6hr
Nitroglycerin	Start Date: 2007-03-29 / Dosis: 3ml/hr / Route: IV / Frequency: Once
Lovenox	Start Date: 2007-03-29 / Dosis: 30mg / Route: SC / Frequency: bid

PROBLEM LIST

Problem	Start Date	End Start
Acute Pneumonia	mar/29/07 12:00 AM	abr/04/07 12:00 AM

VITAL SIGNS

Date	BP	Resp	Weight	Temp	O2Sat	Pulse
abr/02/07 12:00:AM	130 / 60	20	129	37.0	80	74
abr/02/07 12:00:AM	120 / 80	20	129	36.0	75	80
abr/02/07 12:00:AM	120 / 80	20	129	36.0	70	88
abr/01/07 12:00:AM	110 / 60	20	129	37.0	80	80

LABORATORY & EXAMS

Name	Details
Lab: Parvovirus	Dosis: Parvovirus / Frequency: once / Hour: null

Figure 3.3 Patient's Summary Interface

3.3.3 Orders Interface

The Orders interface is selected by clicking on the Orders tab. The purpose of this interface is to provide physicians a means to generate one or more medical orders at a time. Its user interface (See Figure 3.4a, Figure 3.4b) provides at the left side tabs for specific orders such as medication, laboratories, diagnostic studies, consultations, restrictions, diets and other general orders.

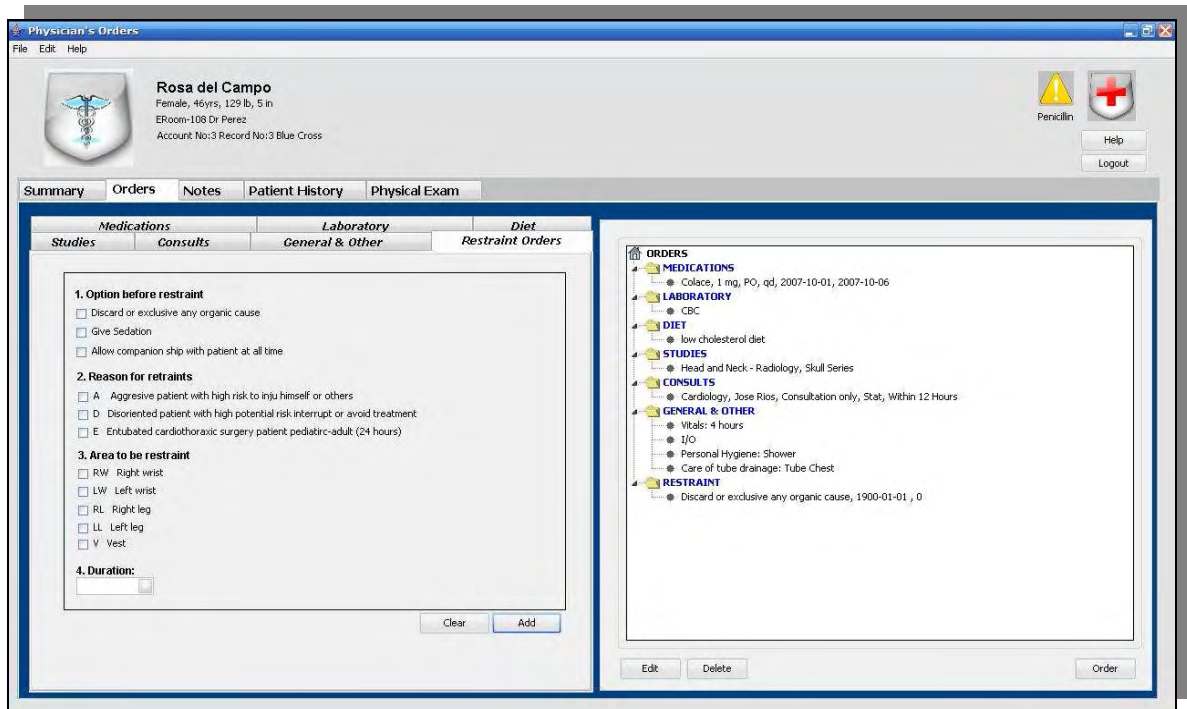


Figure 3.4a Orders Interface

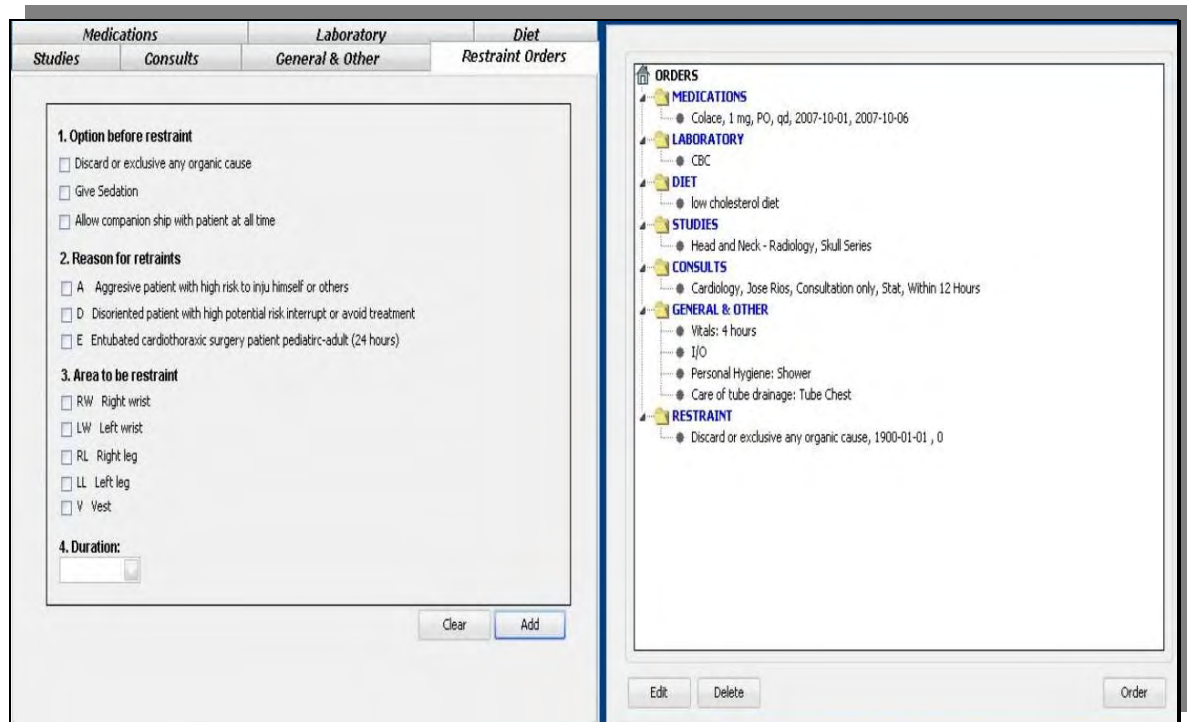


Figure 3.4b Orders Interface Magnified

The right side of the interface displays a tree-like structure that provides feedback on the orders specified by the physician. At the top level of the tree are all the orders categories. The next level indicates all the orders entered by the physician for a particular order category. The physician has the option of collapsing or exposing the entries of any order category by clicking on the category label on the tree. Any order can be deleted from the tree or edited by selecting it and clicking on the Delete or Edit buttons at the lower left corner of the right side of the Orders interface respectively. When the Edit option is selected for a particular order the left side of the Orders interface will display the information corresponding to that order. The orders that appear on the tree are passed to the patient's record when the Order button at the lower right corner of the right side of the Orders interfaces is selected. The following sections describe each ordering option.

3.3.3.1 Medications Orders Interface

The medication orders interface is shown in figure 3.5a and figure 3.5b at the right side of the Orders interface. This interface allows physicians to order medications for many purposes. It provides a list of all medications stored in the system. To speedup the selection of the medication a text box is provided at the top of the list that auto-searches the list as the physician types in the characters of the name of the medication. When a match is found the name of the medication appears in the text box. If no medication on the database matches the name entered, it can still be ordered but a warning is given to the physician that the medication has not been validated. In addition to the text box for the medication name there

are three combo boxes to specify the dose, route, and frequency of the medication. Alternatively, these attributes can be specified by simply typing in the corresponding text box. In addition the interface provides the option for specifying the medication starting and ending date or a Stat medication (immediate administration). Any additional information or detail concerning a medication can be entered in the Detail text field provided at the bottom of the interface. The physician can add the order to the tree on the right side of the Orders interface by selecting the Add button at the lower left corner of the Medication interface. The physician may as well clear an order by selecting the Clear button at the lower right corner of the interface.

The screenshot displays the 'Physician's Orders' application window. At the top, a patient profile for 'Rosa del Campo' is shown, including her age (46 yrs), weight (129 lb), height (5 in), and room number (ERoom-108). The interface is divided into several tabs: 'Summary', 'Orders', 'Notes', 'Patient History', and 'Physical Exam'. The 'Orders' tab is active, and within it, the 'Medications' sub-tab is selected. On the left, a list of medications is provided, with 'Abciximab' currently selected. To the right of this list are input fields for 'Dose', 'Route', and 'Frequency', each with a dropdown menu. Below these are 'Start Date' and 'End Date' fields with calendar icons, and a checkbox for 'Stat'. A 'Details' text area is at the bottom left. On the right side of the window, an 'ORDERS' tree view shows a hierarchy: 'MEDICATIONS' (expanded), 'LABORATORY', 'DIET', 'STUDIES', 'CONSULTS', 'GENERAL & OTHER', and 'RESTRAINT'. The 'MEDICATIONS' node contains a single entry: 'Abciximab, 0.5 mg, PO, qd, 2007-10-02, 2007-10-06, Stat: Yes'. At the bottom right, there are buttons for 'Edit', 'Delete', and 'Order'. A 'Clear' button is located at the bottom center of the medication entry form.

Figure 3.5a Medication Tab

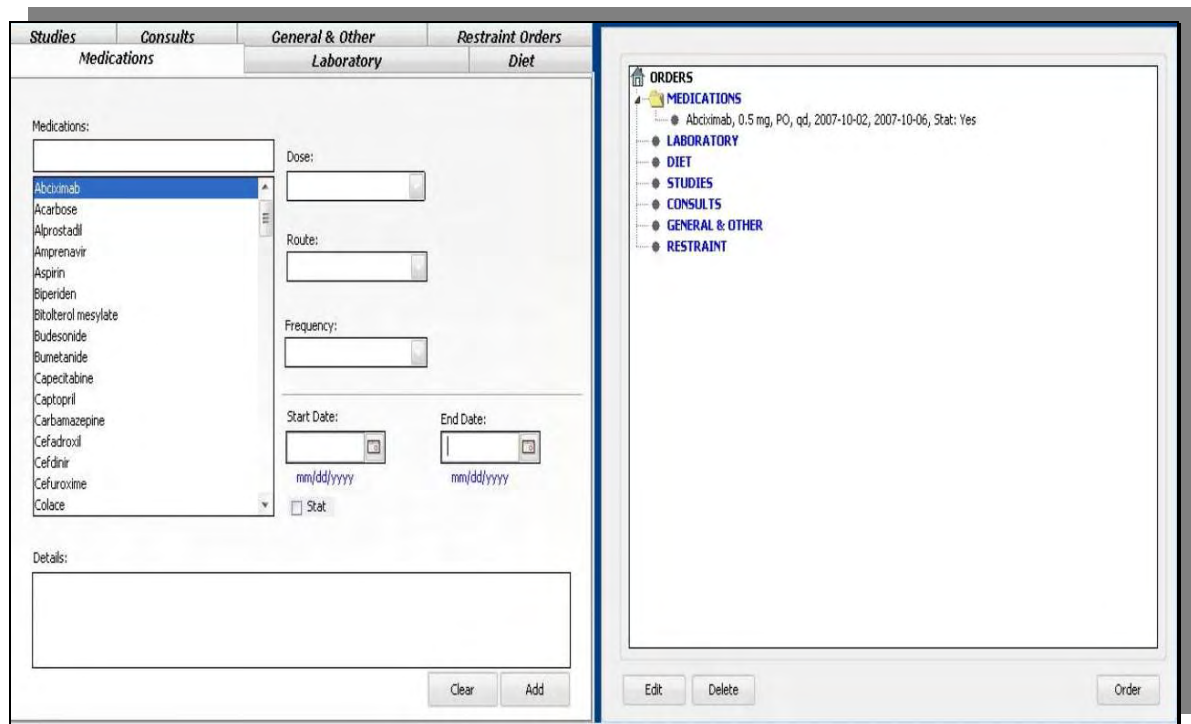
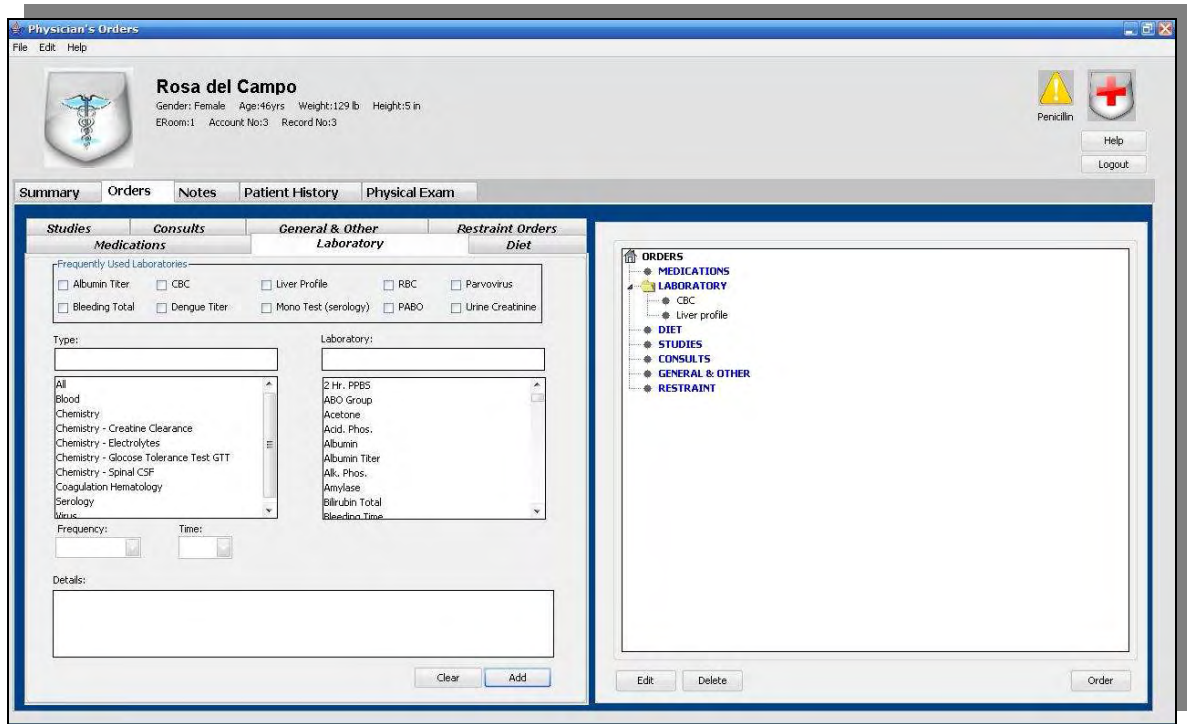


Figure 3.5b Medication Tab Magnified

3.3.3.2 Laboratory Orders Interface

The tab for ordering laboratories is shown at the left hand side of the interface shown in figure 3.6a and figure 3.6b. The interface provides check boxes for selecting the most common laboratories. It also provides a list of laboratory types at the left side and a list of laboratories corresponding to a particular laboratory at the right side. A text box at the top of each the list allows for auto-searching. Once a laboratory type is selected on the left side list the list on the right displays laboratories corresponding to that category. At the bottom of the interface there are two combo boxes that may be used for specifying a frequency and a starting time if necessary. In addition it provides a text field for providing any detail or specification for the laboratory. A laboratory is added to the tree on the right side of the

interface by selecting the Add button at the lower right corner of the laboratory order interface. It can also be cleared by selecting the Clear button also at the lower right side of the laboratory order interface.



The screenshot displays the 'Physician's Orders' software window. At the top, a patient header for 'Rosa del Campo' includes demographic data: Gender: Female, Age: 46 yrs, Weight: 129 lb, Height: 5 in, ERoom: 1, Account No: 3, and Record No: 3. Navigation tabs include Summary, Orders, Notes, Patient History, and Physical Exam. The 'Orders' tab is active, showing sub-tabs for Studies, Consults, General & Other, and Restraint Orders. The 'Laboratory' sub-tab is selected, revealing a 'Frequently Used Laboratories' section with checkboxes for Albumin Titer, CBC, Liver Profile, RBC, Parvovirus, Bleeding Total, Dengue Titer, Mono Test (serology), PABO, and Urine Creatinine. Below this are input fields for Type, Laboratory, Frequency, and Time, followed by a Details text area. A 'Clear' button and an 'Add' button are at the bottom right of this section. On the right side of the window, an 'ORDERS' tree view lists categories: MEDICATIONS, LABORATORY (selected), DIET, STUDIES, CONSULTS, GENERAL & OTHER, and RESTRAINT. At the bottom of this panel are 'Edit', 'Delete', and 'Order' buttons.

Figure 3.6a Laboratory Tab Interface

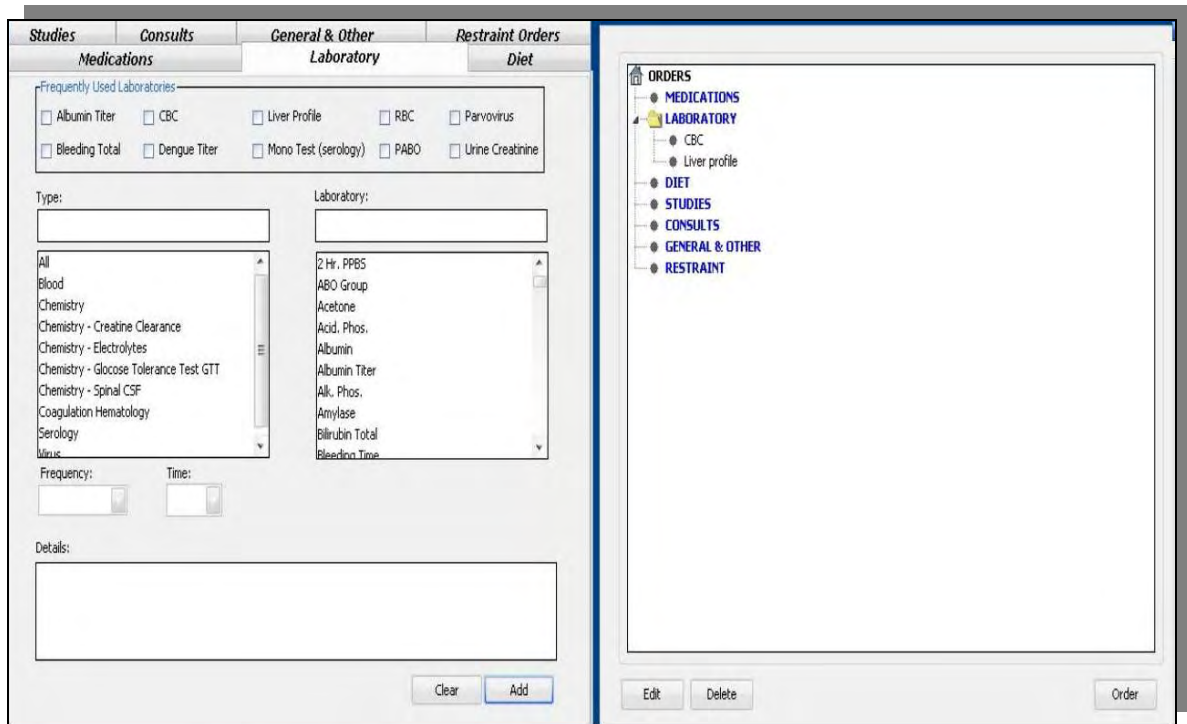


Figure 3.6b Laboratory Tab Interface Magnified

3.3.3.3 Studies Orders Interface

The studies interface is very similar to the laboratories orders interface (See figure 3.7a and figure 3.7b). It provides check boxes for selecting the most frequent studies. It provides a list of studies categories and a list of studies for the category selected. It also provides combo boxes for specifying frequency and starting time as well as a text field for details or specifications for the study.

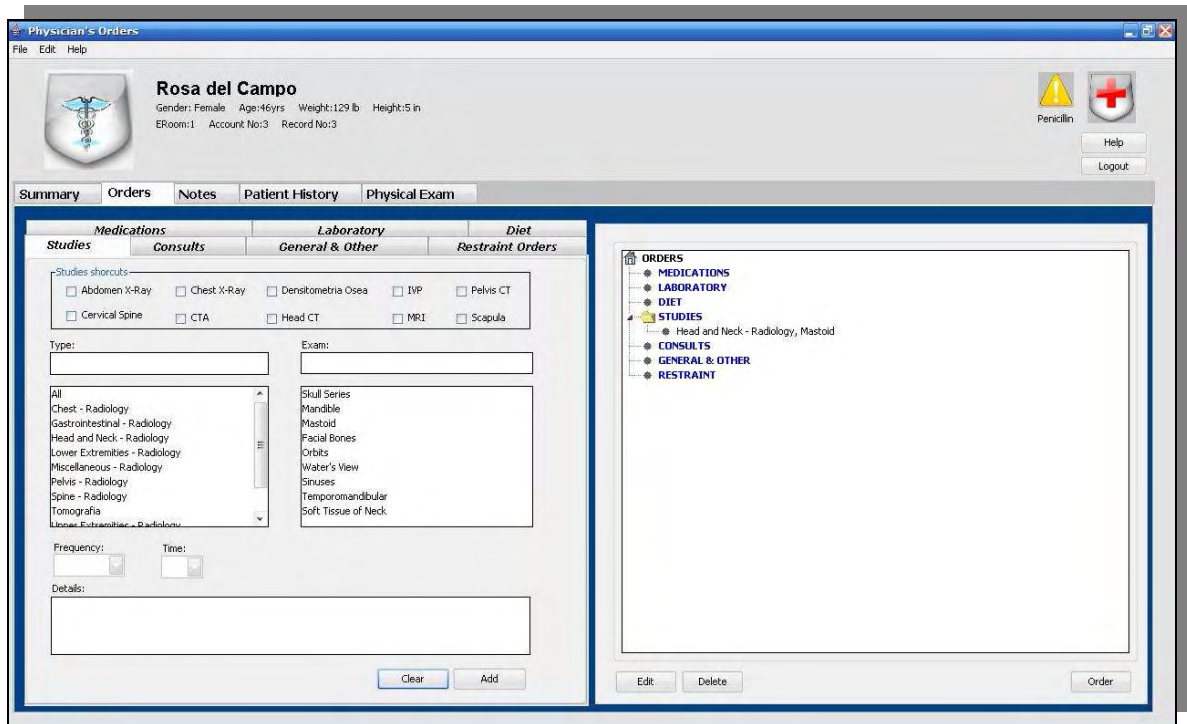


Figure 3.7a Studies Tab Interface

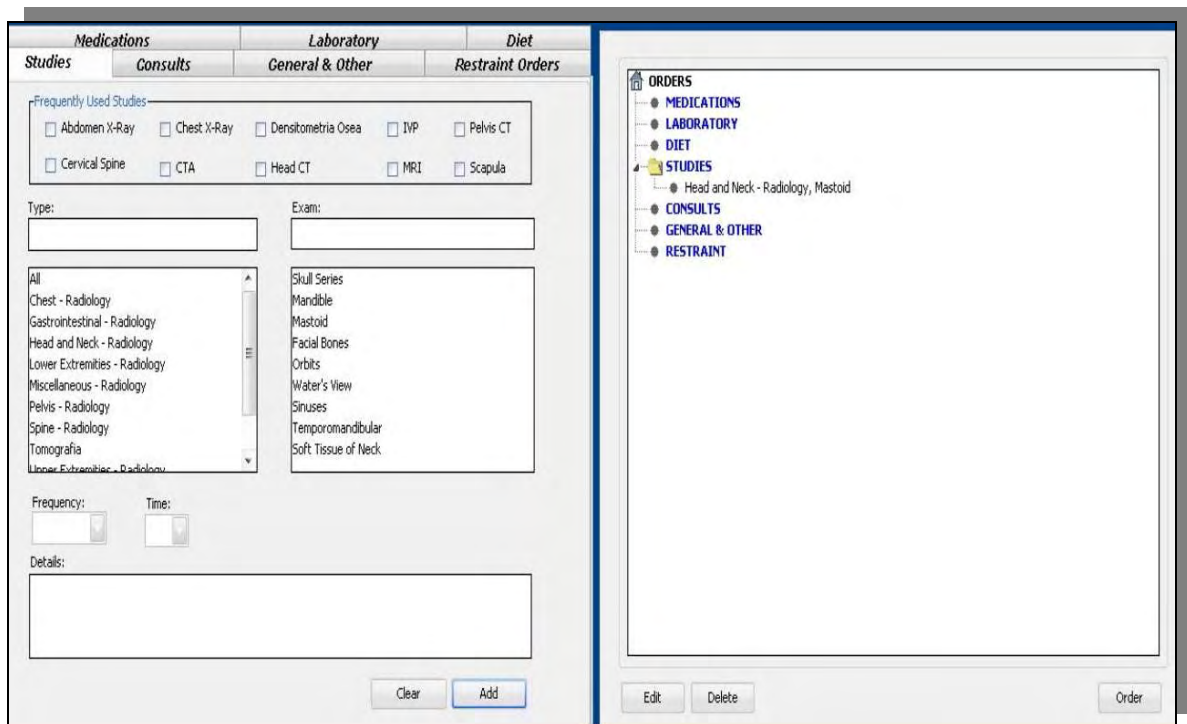


Figure 3.7b Studies Tab Interface Magnified

3.3.3.4 Diet Orders Interface

This interface (See figure 3.8a and figure 3.8b) is very similar to laboratory orders interface. It provides check boxes for selecting the most frequent diets. It provides a diet category list and a list of diets for the selected category. A text field is provided at the bottom of the interface for providing details and specifications for the selected diet(s).

The screenshot shows the 'Physician's Orders' window for patient Rosa del Campo. The patient's demographic information is displayed at the top: Gender: Female, Age: 46yrs, Weight: 129 lb, Height: 5 in, ERoom: 1, Account No: 3, Record No: 3. The interface has a tabbed menu with 'Summary', 'Orders', 'Notes', 'Patient History', and 'Physical Exam'. The 'Orders' tab is active, showing sub-tabs for 'Studies', 'Consults', 'General & Other', and 'Laboratory'. The 'Diet' sub-tab is selected, displaying a list of diet shortcuts with checkboxes for selection. The list includes: Blended, Clear liquid, Diabetic, Dietician Consult, Enteral Nutrition, Full Liquid, Irritants Free, Jevity Diet, Low Protein Diet, Low Cholesterol, Low Fat Low Chol, NPO, Regular, Renal, and SMA. Below the list are text fields for 'Type:' and 'Diet:', and a large text area for 'Details:'. At the bottom are 'Clear' and 'Add' buttons. On the right side, there is a tree view of the 'ORDERS' menu, with 'LABORATORY' and 'DIET' expanded. The 'DIET' menu shows a list of diet categories: low protein diet, low cholesterol diet, and a list of diet types: Blended, Clear liquid, Diabetic, Dietician Consult, Enteral Nutrition, Full Liquid, Irritants Free, Jevity Diet, Low Protein Diet, Low Cholesterol, Low Fat Low Chol, NPO, Regular, Renal, and SMA. At the bottom right are 'Edit', 'Delete', and 'Order' buttons.

Figure 3.8a Diet Tab Interface

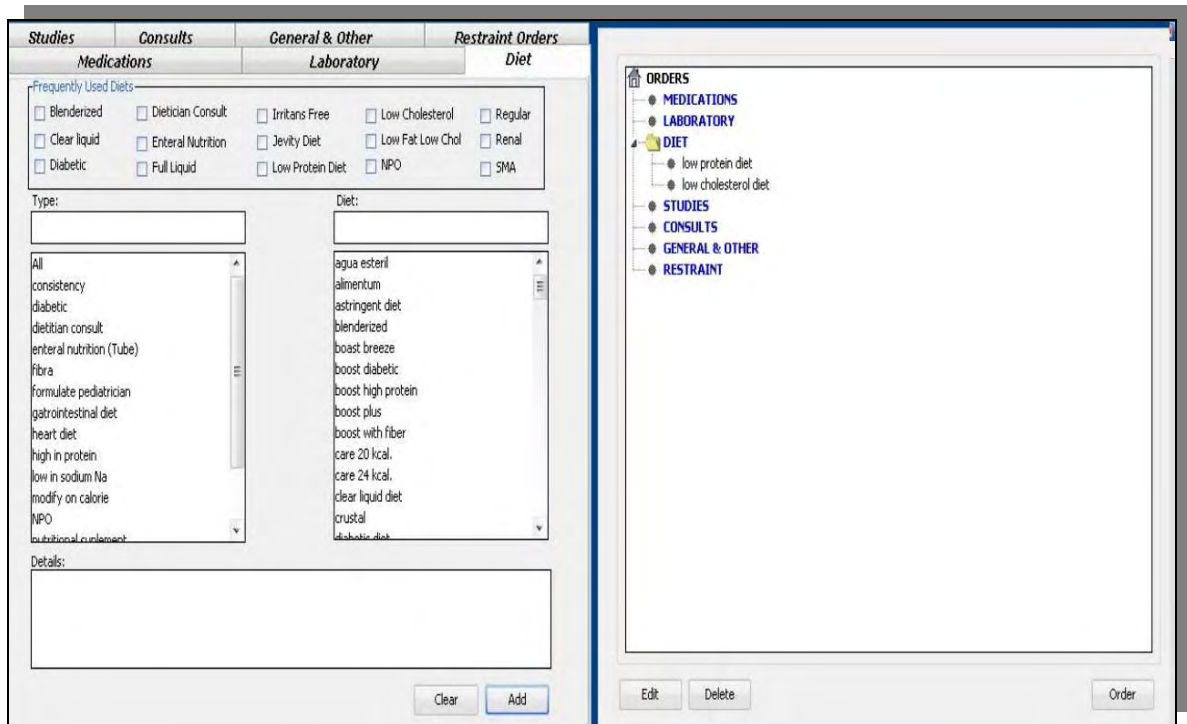


Figure 3.8b Diet Tab Interface Magnified

3.3.3.5 Consults Orders Interface

The consults orders interface (see figure 3.9a and figure 3.9b) allows requesting consultations from other physicians or specialists. At the top of the interface three options are provided. The first one is Reason Consult: it determines the consultation type that has been requested, such as *Consultation Only*, *Consult and Follow Up* and *Please Feel Free to Order*. The second option is Stat up: it indicates if the consultation should be immediate (*Stat*) or out patient (*OPD*). The third option is “Within”: it indicates the time frame when the consult should take place (*12 hours* or *24 hours*).

There are also two lists, one for selecting a medicine specialty and the other to select a physician within the selected specialty. A text field is provided at the bottom of the interface for providing details or comments to the physician consulted.

The screenshot shows a web application window titled "Physician's Orders". At the top, there is a patient information section for "Rosa del Campo", including gender (Female), age (46 yrs), weight (129 lb), height (5 in), ER room (1), account number (3), and record number (3). Below this is a navigation bar with tabs: Summary, Orders, Notes, Patient History, and Physical Exam. The "Orders" tab is active, and within it, the "Consults" sub-tab is selected. The main area is divided into two columns. The left column contains form fields for "Reason Consult" (with radio buttons for "Consultation only", "Consult and follow up", and "Please feel free to order"), "Stat up" (with radio buttons for "Stat" and "OPD"), "Within" (with radio buttons for "12 hours" and "24 hours"), "Specialty" (a dropdown menu with a list of specialties including Cardiology, Cardiovascular surgery, Dermatology, Endocrinology, ENT, Gastroenterology, Generalista, Internal medicine, Lung surgery, and Nephrology), "Physicians" (a list of names: Bartolo Colon, James Mendez, Jose Rios, Luis Rivera, and Pedro Mendez), and a "Details" text area. The right column displays a tree view of "ORDERS" with categories: MEDICATIONS, LABORATORY, DIET, STUDIES, CONSULTS, GENERAL & OTHER, and RESTRAINT. The "CONSULTS" category is expanded, showing a single entry: "Endocrinology, Bartolo Colon, Consultation only, Stat, Within 12 Hours". At the bottom right of the "ORDERS" panel are buttons for "Edit", "Delete", and "Order".

Figure 3.9a Consults Tab Interface

Figure 3.9b Consults Tab Interface Magnified

3.3.3.6 Restraint Order Interface

The interface for Restraint Orders is shown in figure 3.10. It provides check boxes for specifying options before restraint, reasons for restraining the patient, and the area to be restraint. In addition it provides a field for specifying the duration of the restraint.

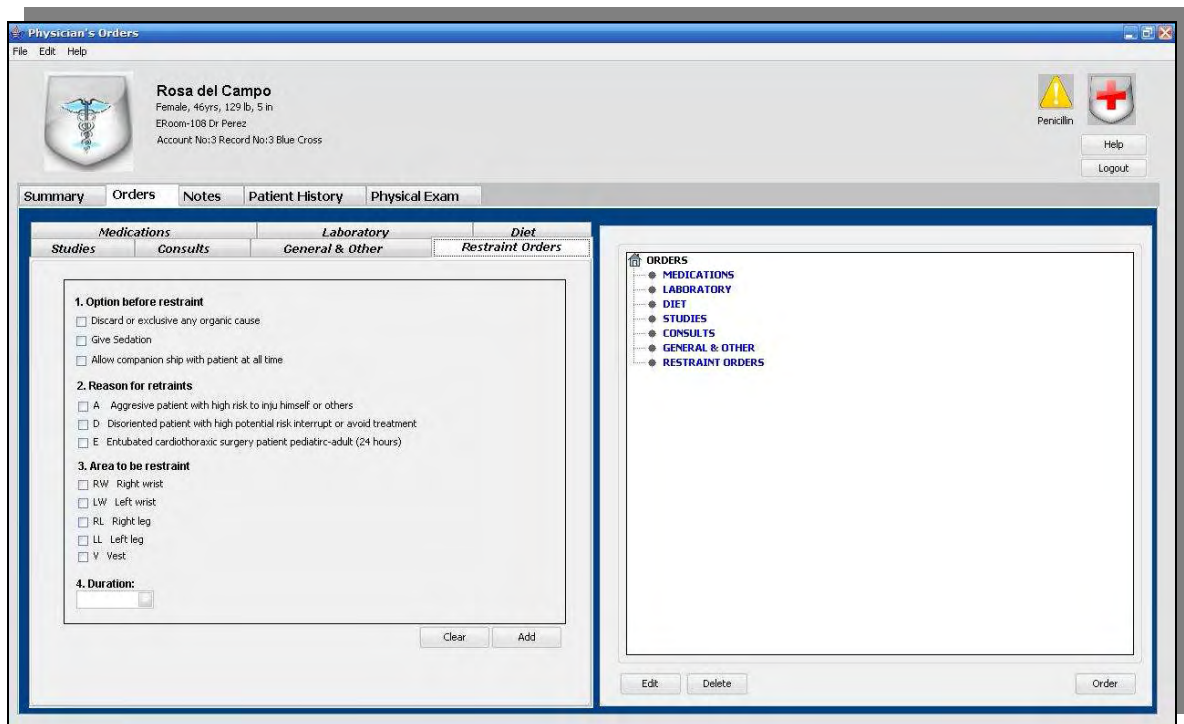


Figure 3.10 Restraint Order Tab Interface

3.3.3.7 General & Other Orders Interface

The General & Other orders interface is shown in figure 3.11. It provides a combo box for specifying the frequency vital signs should be taken and a check box for ordering Intake/Output of fluids collection. It also provides combo boxes for specifying orders such as personal hygiene, ambulation, care of tube drainage, physical therapy and respiratory therapy. A text field is provided beside these orders categories to enter another option not available on the combo boxes.

Any order that is not supported with any of the orders tabs can be specified with the Generic text field provided at the bottom left corner of the interface. Details related to any of the orders supported by the General & Others order interface can be entered on the Details text field provided at the lower right side of the interface.

The screenshot displays the 'Physician's Orders' application window. At the top, a patient header identifies 'Rosa del Campo' as a 46-year-old female, 129 lb, 5 in, with room 108 and Dr. Perez as the attending physician. Below this is a tabbed interface with 'Orders' selected. The 'Orders' tab is further divided into sub-tabs: 'Medications', 'Laboratory', 'Diet', 'Studies', 'Consults', 'General & Other', and 'Restraint Orders'. The 'General & Other' sub-tab is active, showing a grid of input fields for various medical orders. These include 'Vital Signs' (4 hours), 'Personal Hygiene' (None), 'Ambulatory' (None), 'Care of tube drainage' (None), 'Physical Therapy' (None), 'Respiratory Therapy' (None), and a 'Generic' text field at the bottom. To the right of these fields is a tree view of the 'ORDERS' menu, with 'GENERAL & OTHER' expanded and selected. The interface also includes a 'Pericillin' warning icon, a 'Help' button, and a 'Logout' button in the top right corner.

Figure 3.11 General Order Tab Interface

3.3.4 Notes Interface

The Progress Notes tab (See figure 3.12) features a list of the notes that have been written by physicians and nurses. The list indicates the date, the note type, the author and user's type. The list can be sorted by any of these attributes. When a note is selected from the list its corresponding text is displayed on the right side of the interface.

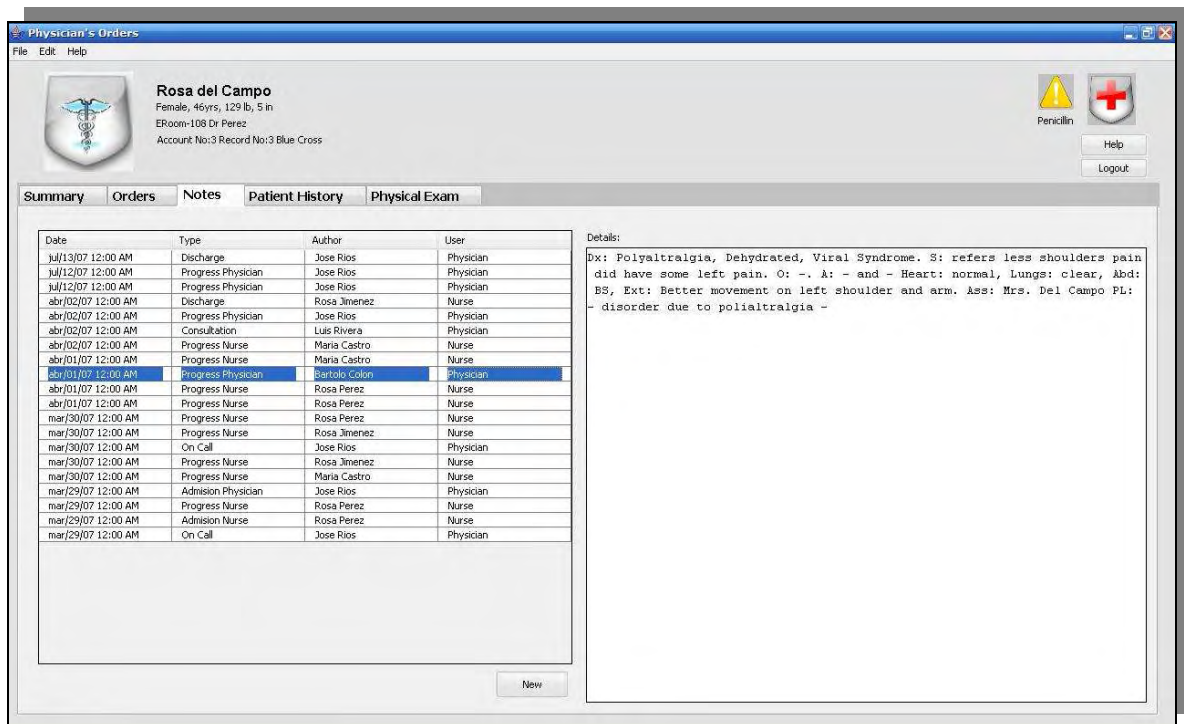


Figure 3.12 Notes Tab Interface

A New button at the bottom of the interface is provided for opening the interface for entering a new note. This interface is shown in figure 3.13. It is divided in two sections. A section on the left is provided for creating a new note. It provides a combo box for specifying the note type and a text field for writing the note. In addition it provides a check box that automatically inserts the keywords of the active problems of the patient in case the physician desires to address one or more of these problems on the note. The note can be saved by selecting the Save button at the bottom of the interface or canceled by selecting the Cancel button.

Problem	Start Date	End Start
Acute Pneumonia	mar/29/07 12:00 AM	abr/04/07 12:00 AM

Figure 3.13 New Note Interface

The section on the right side of the interface provides the problem list of the patient. Each entry indicates the starting and ending dates of the problem. An end date for a problem can be specified by selecting the problem and then the End Date button at the bottom of the interface. A new problem can be added to the patient by selecting the “New” button at the bottom of the interface. This action opens a window in which the physician can select a new problem from a list (See figure 3.14).

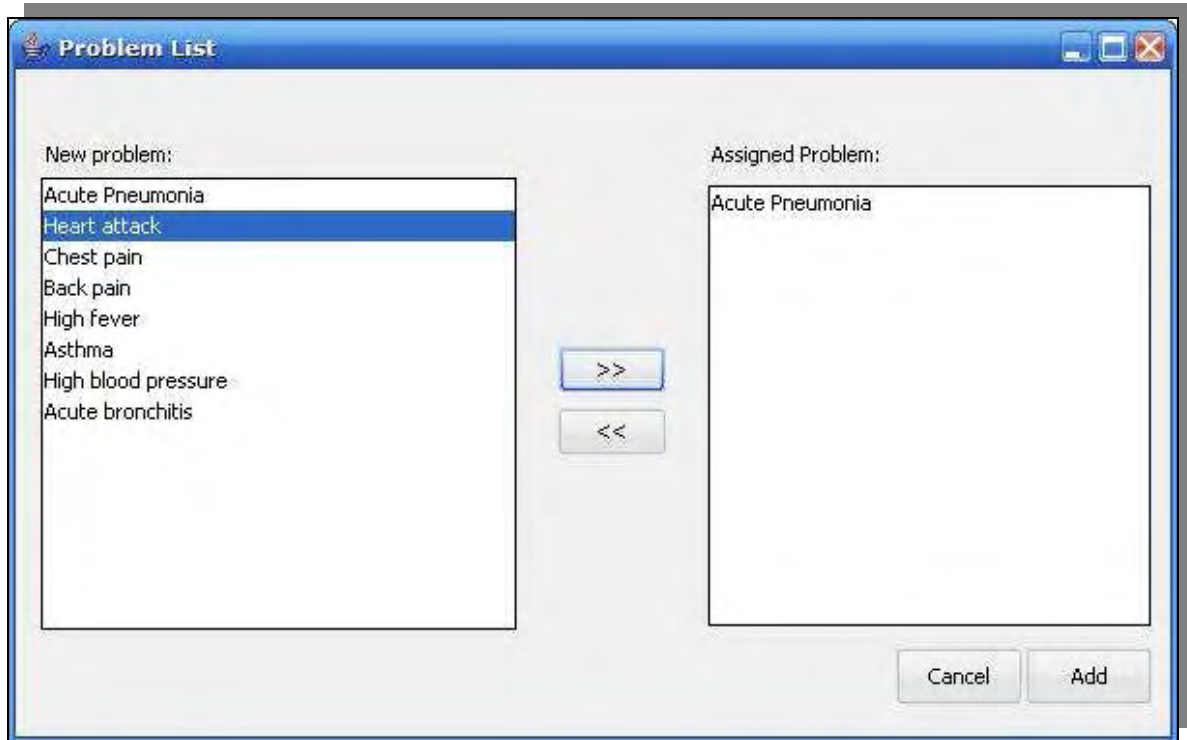


Figure 3.14 New Problem List Interface

3.3.5 Patient History Interface

The Patient History interface features two tabs: Historical Exams and Review of Systems (See figure 3.15). The Historical Exams tab shown in figure 3.15 provides text fields for documenting chief complaints, history of present illness and past history (allergies and medications). It also provides check boxes for indicating patient's conditions and a text field for additional comments on patient conditions. Check boxes are provided for indicating aspect of the social history of the patient and text fields for additional comments on each aspect. Radio buttons for indicating if the father and mother are alive or deceased are provided, as well as a text field for additional comments regarding the mother and father.

Check boxes are provided for indicating family diseases and a text field for providing additional information about them.

Figure 3.15 Patient History Interface

The second tab within the Patient History is the Review Systems tab (See figure 3.16a and figure 3.16b). It provides radio buttons for indicating if the patient has (Yes) or does not have (No) an abnormal condition on any of her/his body systems. If an abnormal condition is indicated it can be documented on the text field provided on the right side of each aspect of each system evaluated. The Systems or organs evaluated are: General, Skin, Head and Neck, Chest, Back and Spine, Abdomen, Genitalia, Rectal, Extremities, Lymphatic System, Neurologic, Pain and Functional Risk Criteria.

Physician's Orders

File Edit Help

Rosa del Campo
Female, 46yrs, 129 lb, 5 in
ERoom-108 Dr Perez
Account No:3 Record No:3 Blue Cross

Pericillin

Help
Logout

Summary Orders Notes Patient History Physical Exam

Historical Exams Review of Systems

LOCATION	YES	NO	IF YES, SPECIFY
General	<input type="radio"/>	<input type="radio"/>	
Skin	<input type="radio"/>	<input type="radio"/>	
Head and Neck	<input type="radio"/>	<input type="radio"/>	
Eyes	<input type="radio"/>	<input type="radio"/>	
Nose	<input type="radio"/>	<input type="radio"/>	
Ears	<input type="radio"/>	<input type="radio"/>	
Throat	<input type="radio"/>	<input type="radio"/>	
Mouth	<input type="radio"/>	<input type="radio"/>	
Thyroid	<input type="radio"/>	<input type="radio"/>	
Chest	<input type="radio"/>	<input type="radio"/>	
Breast	<input type="radio"/>	<input type="radio"/>	
Heart	<input type="radio"/>	<input type="radio"/>	
Lungs	<input type="radio"/>	<input type="radio"/>	
Back and Spine	<input type="radio"/>	<input type="radio"/>	
Abdomen	<input type="radio"/>	<input type="radio"/>	
Liver	<input type="radio"/>	<input type="radio"/>	
Spleen	<input type="radio"/>	<input type="radio"/>	
Kidney	<input type="radio"/>	<input type="radio"/>	
Genitalia	<input type="radio"/>	<input type="radio"/>	
External	<input type="radio"/>	<input type="radio"/>	
Pelvic	<input type="radio"/>	<input type="radio"/>	
Rectal	<input type="radio"/>	<input type="radio"/>	
Extremities	<input type="radio"/>	<input type="radio"/>	
Lymphatic System	<input type="radio"/>	<input type="radio"/>	
Neck	<input type="radio"/>	<input type="radio"/>	
Axilla	<input type="radio"/>	<input type="radio"/>	

Cancel Save

Figure 3.16a Review System Interface – Part I

Physician's Orders

File Edit Help

Rosa del Campo
Female, 46yrs, 129 lb, 5 in
ERoom-108 Dr Perez
Account No:3 Record No:3 Blue Cross

Pericillin

Help
Logout

Summary Orders Notes Patient History Physical Exam

Historical Exams Review of Systems

LOCATION	YES	NO	IF YES, SPECIFY
Kidney	<input type="radio"/>	<input type="radio"/>	
Genitalia	<input type="radio"/>	<input type="radio"/>	
External	<input type="radio"/>	<input type="radio"/>	
Pelvic	<input type="radio"/>	<input type="radio"/>	
Rectal	<input type="radio"/>	<input type="radio"/>	
Extremities	<input type="radio"/>	<input type="radio"/>	
Lymphatic System	<input type="radio"/>	<input type="radio"/>	
Neck	<input type="radio"/>	<input type="radio"/>	
Axilla	<input type="radio"/>	<input type="radio"/>	
Grain	<input type="radio"/>	<input type="radio"/>	
Neurologic	<input type="radio"/>	<input type="radio"/>	
Mental Status	<input type="radio"/>	<input type="radio"/>	
Cranial Nervous Function	<input type="radio"/>	<input type="radio"/>	
Motor and Sensory Functions	<input type="radio"/>	<input type="radio"/>	
Reflexes	<input type="radio"/>	<input type="radio"/>	
Pain	<input type="radio"/>	<input type="radio"/>	
Functional Risk Criteria	<input type="radio"/>	<input type="radio"/>	
Loss of Mobility	<input type="radio"/>	<input type="radio"/>	
Loss of Muscular Force	<input type="radio"/>	<input type="radio"/>	
History of CVA	<input type="radio"/>	<input type="radio"/>	
Musculoskeletal condition	<input type="radio"/>	<input type="radio"/>	
Neurologic Deficit	<input type="radio"/>	<input type="radio"/>	
Amputation	<input type="radio"/>	<input type="radio"/>	
Ulcer of Open Wound	<input type="radio"/>	<input type="radio"/>	
Prolonged Immobility	<input type="radio"/>	<input type="radio"/>	
Physical Medicine & Rehabilitation	<input type="radio"/>	<input type="radio"/>	

Cancel Save

Figure 3.16b Review System Interface – Part II

3.3.6 Physical Examination Interface

The components of physical assessment are the survey and examination of systems. The interface for the physical examination is shown in figures 3.17. It provides checkboxes for recording the patients' health with respect to the following systems and organs: General, Skin, Head and Eyes, Ears, Nose and Throat, Neck, Chest, Breasts, Heart, Lungs, Genitalia Male, Genitalia Female, Anus and Rectum, Extremities, Neurologic and Lymphatic. If an abnormal condition is detected this can be described in the text field provided at the right side of the condition entry. Text fields are provided for documenting a diagnostic impression and specifying a treatment plan.

The screenshot shows a software window titled "Physician's Orders" with a menu bar (File, Edit, Help). The patient information section displays "Rosa del Campo", Female, 46yrs, 129 lb, 5 in, ERoom-108 Dr Perez, Account No:3 Record No:3 Blue Cross. There are icons for Penicillin and a red cross, along with Help and Logout buttons. The "Physical Exam" tab is selected, showing a table with columns "LOCATION" and "DESCRIBE ABNORMALITIES". The table is divided into sections: General, Skin, and Head and Eyes. Each section has a list of conditions with checkboxes. Below the table are text fields for "Diagnostic Impressions:" and "Treatment Plan:", and "Cancel" and "Save" buttons.

LOCATION	DESCRIBE ABNORMALITIES
General	
<input type="checkbox"/> Normal	
<input type="checkbox"/> Disoriented	
<input type="checkbox"/> Undernourished	
<input type="checkbox"/> Comatose	
<input type="checkbox"/> Acutely ill	
<input type="checkbox"/> Chronically ill	
<input type="checkbox"/> Non-responsive	
Skin	
<input type="checkbox"/> Normal	
<input type="checkbox"/> Pale	
<input type="checkbox"/> Cyanotic	
<input type="checkbox"/> Jaundice	
<input type="checkbox"/> Erythemas	
<input type="checkbox"/> Petechiae	
<input type="checkbox"/> Rash	
<input type="checkbox"/> Other	
Head and Eyes	
<input type="checkbox"/> Normal	
<input type="checkbox"/> Non reactive pupils	
<input type="checkbox"/> Cataracts	
<input type="checkbox"/> Unequal Pupils	
<input type="checkbox"/> Scleral icterus	
<input type="checkbox"/> Strabismus	


Diagnostic Impressions:



Treatment Plan:

Cancel Save

Figure 3.17a Physical Examination – Part I

Physician's Orders
File Edit Help

 **Rosa del Campo**
Female, 46yrs, 129 lb, 5 in
ERoom-108 Dr Perez
Account No:3 Record No:3 Blue Cross

Penicillin  
Help
Logout

Summary Orders Notes Patient History **Physical Exam**

Physical Examination

LOCATION		DESCRIBE ABNORMALITIES
Ears	<input type="checkbox"/> Normal	
	<input type="checkbox"/> Otitis	
	<input type="checkbox"/> Perforated ear drums	
	<input type="checkbox"/> Deafness	
	<input type="checkbox"/> Otosclerosis	
	<input type="checkbox"/> Other	
Nose and Throat	<input type="checkbox"/> Normal	
	<input type="checkbox"/> Nasal Discharge	
	<input type="checkbox"/> Polyps	
	<input type="checkbox"/> Deviated Septum	
	<input type="checkbox"/> Enlarged Tonsils	
Neck	<input type="checkbox"/> Normal	
	<input type="checkbox"/> Enlarged Thyroid	
	<input type="checkbox"/> Neck Rigidity	
	<input type="checkbox"/> Thyroid nodule	
	<input type="checkbox"/> Distended Jugular Veins	
	<input type="checkbox"/> Bruit	
	<input type="checkbox"/> Displaced trachea	
	<input type="checkbox"/> Abnormal Carotid Pulses	
	<input type="checkbox"/> Adenopathy	


Diagnostic Impressions:



Treatment Plan:

Cancel Save

Figure 3.17b Physical Examination – Part II

Physician's Orders
File Edit Help

 **Rosa del Campo**
Female, 46yrs, 129 lb, 5 in
ERoom-108 Dr Perez
Account No:3 Record No:3 Blue Cross

Penicillin  
Help
Logout

Summary Orders Notes Patient History **Physical Exam**

Physical Examination

LOCATION		DESCRIBE ABNORMALITIES
Chest	<input type="checkbox"/> Normal	
	<input type="checkbox"/> Asymmetrical	
	<input type="checkbox"/> Increased A-P diameter	
	<input type="checkbox"/> Retractions	
Breasts	<input type="checkbox"/> Normal	
	<input type="checkbox"/> Masses	
	<input type="checkbox"/> Tenderness	
	<input type="checkbox"/> Nipple Discharge	
	<input type="checkbox"/> Nipple Retraction	
Heart	<input type="checkbox"/> Normal	
	<input type="checkbox"/> Murmur	
	<input type="checkbox"/> Gallops	
	<input type="checkbox"/> Thrill	
	<input type="checkbox"/> Rubs	
	<input type="checkbox"/> Arrhythmia	
	<input type="checkbox"/> Extrasystoles	
	<input type="checkbox"/> Heaves	
Lungs	<input type="checkbox"/> Normal	
	<input type="checkbox"/> Rales	


Diagnostic Impressions:



Treatment Plan:

Cancel Save

Figure 3.17c Physical Examination – Part III

Physician's Orders
File Edit Help

 **Rosa del Campo**
Female, 46yrs, 129 lb, 5 in
ERoom-108 Dr Perez
Account No:3 Record No:3 Blue Cross

 
Penicillin
Help
Logout

Summary Orders Notes Patient History **Physical Exam**

Physical Examination

LOCATION	DESCRIBE ABNORMALITIES
Lungs	
<input type="checkbox"/> Normal	
<input type="checkbox"/> Rales	
<input type="checkbox"/> Wheezing	
<input type="checkbox"/> Rhonchi	
<input type="checkbox"/> Dullness	
<input type="checkbox"/> Decreased Breath Sounds	
<input type="checkbox"/> Ribs	
Abdomen	
<input type="checkbox"/> Normal	
<input type="checkbox"/> Masses	
<input type="checkbox"/> Tympany	
<input type="checkbox"/> Decreased Peristalsis	
<input type="checkbox"/> Tenderness	
<input type="checkbox"/> Fluid wave	
<input type="checkbox"/> Rebound Tenderness	
<input type="checkbox"/> Splenomegaly	
<input type="checkbox"/> Hepatomegaly	
<input type="checkbox"/> Increased Peristalsis	
<input type="checkbox"/> Distention	
<input type="checkbox"/> Hernias	
<input type="checkbox"/> Guarding	
<input type="checkbox"/> Scars	
Genitalia Male	


Diagnostic Impressions:



Treatment Plan:

Cancel Save

Figure 3.17d Physical Examination – Part IV

Physician's Orders
File Edit Help

 **Rosa del Campo**
Female, 46yrs, 129 lb, 5 in
ERoom-108 Dr Perez
Account No:3 Record No:3 Blue Cross

 
Penicillin
Help
Logout

Summary Orders Notes Patient History **Physical Exam**

Physical Examination

LOCATION	DESCRIBE ABNORMALITIES
Genitalia Male	
<input type="checkbox"/> Normal	
<input type="checkbox"/> Penile Lesions	
<input type="checkbox"/> Varicose Veins	
<input type="checkbox"/> Phymosis	
<input type="checkbox"/> Enlarged prostate	
<input type="checkbox"/> Balanitis	
<input type="checkbox"/> Prostatic nodule	
<input type="checkbox"/> Scrotal Masses	
<input type="checkbox"/> Prostatic Tenderness	
<input type="checkbox"/> Testicular Masses	
Genitalia Female	
<input type="checkbox"/> Normal	
<input type="checkbox"/> Vulvar Lesions	
<input type="checkbox"/> Cystocele	
<input type="checkbox"/> Vulvar varices	
<input type="checkbox"/> Rectocele	
<input type="checkbox"/> Vaginal Discharge	
<input type="checkbox"/> Uterine Enlargement	
<input type="checkbox"/> Uterine Prolapse	
<input type="checkbox"/> Pelvic	
Anus and Rectum	
<input type="checkbox"/> Normal	
<input type="checkbox"/> Fissures	

Diagnostic Impressions:


Treatment Plan:

Cancel Save



Figure 3.17e Physical Examination – Part V

Physician's Orders

File Edit Help



Rosa del Campo
 Female, 46yrs, 129 lb, 5 in
 ERoom-108 Dr Perez
 Account No:3 Record No:3 Blue Cross



 Penicillin
 Help
 Logout

Summary Orders Notes Patient History **Physical Exam**

Physical Examination

LOCATION	DESCRIBE ABNORMALITIES
<input type="checkbox"/> Hemorrhoids	
<input type="checkbox"/> Masses	
<input type="checkbox"/> Tenderness	
<input type="checkbox"/> Sphincter Tone	
Extremities	
<input type="checkbox"/> Normal	
<input type="checkbox"/> Joint Deformity	
<input type="checkbox"/> Edema	
<input type="checkbox"/> Varicosities	
<input type="checkbox"/> Ulcers	
Neurologic	
<input type="checkbox"/> Normal	
<input type="checkbox"/> Ataxia	
<input type="checkbox"/> Tremors	
<input type="checkbox"/> Sensory	
<input type="checkbox"/> Areflexia	
<input type="checkbox"/> Positive Babinsky	
Lymphatic	
<input type="checkbox"/> Normal	
<input type="checkbox"/> Enlarged Nodes	
<input type="checkbox"/> Tender Nodes	
<input type="checkbox"/> Lymphedema	
<input type="checkbox"/> Muscle Weakness	
<input type="checkbox"/> Atrophy	

Diagnostic Impressions:

Treatment Plan:

Cancel Save

Figure 3.17f Physical Examination – Part VI

4 USABILITY EVALUATION

4.1 Introduction

Observing users in the field is often the best way to determine their usability requirements on the system. Traditional usability depends on a number of factors including how well the functionality fits user needs, how well the flow through the application fits user tasks, and how well the response of the application fits user expectations. We can learn to be better user interface designers by learning design principles and design guidelines. But even the most insightful designer can only create a highly-usable system through a process that involves getting information from people who actually use the system. Usability is the quality of a system that makes it easy to learn, easy to use, easy to remember, error tolerant, and subjectively pleasing [Usabilityfirst07].

Many authors have proposed diverse usability definitions, usually through the enumeration of the different characteristics, attributes or factors by means of those that can be evaluated. Each definition depends on the focus by which usability pretends to be measured [Folmer04]. We will take for this work the most extended definition that is the one offered by the ISO (International Organization for Standardization). This organization defines usability as: *“the grade of effectiveness, efficiency and satisfaction with which*

specific users can achieve specific objectives, in specific use contexts” [ISO98]. In this definition it is noticed that the usability has two attributes:

- Quantifiable in an objective way: the effectiveness or numbers of errors by the user during the development of the tasks and efficiency or time that takes the user to carry out each one of the tasks.
- Quantifiable in a subjective way: the use satisfaction that is measured through the user's interrogation.

Table 4.1 provides a brief description of the characteristics of usability according to [Stcsig07]:

Table 4.1 Usability Characteristics [Stcsig07]

Usability Characteristic	Definition
Learnability	Ability for users to learn the system easily.
Efficiency of use once the system has been learned	Ability for users to save time in their work once they've learned the system.
Error recovery & prevention	When the system presents an error message to users, it gives enough information for them to be able to continue with their work. Better yet, the system helps to prevent errors.
Subjective user satisfaction	Users' overall feelings about the system. Is it pleasant to use?

In the field of human-computer interaction (HCI), one of the most popular inspection-based methods for evaluating usability is the Heuristic Evaluation as described originally by Nielsen and Molich and later refined by Nielsen [Nielsen93]. This method is promoted for its cost efficiency and ease of implementation [Userfocus07]. Heuristic Evaluation is a good method for finding both major and minor problems in a user interface. As one might have expected, major problems are slightly easier to find than minor problems [Useit07].

4.2 Heuristic Evaluation

4.2.1 Procedure

The study described in the next sections was conducted using the personal computer and the Tablet PC versions of the physician documentation system described in the previous chapter. This evaluation was developed with a group of four evaluators with knowledge of human-computer interaction principles and usability engineering. They made the evaluation of the system in an independent way; however they were given a short tutorial of the system before performing the evaluation. They were requested to produce a list of the usability problems of the software and assign a level of severity from 1 to 4, with 1 being a minor error and 4 a catastrophic error. To facilitate the interaction with the interfaces, they were given a list of typical physician's tasks such as: Physician's Orders, Patient History and Physical Examination. The list of tasks used for the evaluation is indicated below.

Physician's Orders:

1. Read the list of patient names.
2. Enter to the record of the patient named "Rosa Del Campo".
3. Read the patient's age and weight.
4. Read the last patient's taken temperature.
5. Insert the following medical orders:
 - a. Medication: Lasix, 40 mg IV, q12h, start today until 31 of the month.
 - b. Laboratory: CBC of Blood.
 - c. Laboratory: PT control of Coagulation Hematology.

- d. Other Order: Input & Output.
 - e. Vital signs every 2 hours.
 - f. Care of tube chest drainage.
 - g. Low Cholesterol diet.
 - h. Consult with physician Bartolo Colón, Endocrinologist for recommendations for management and hypothyroidism.
 - i. Remove the laboratory order of PT Control of Coagulation Hematology.
- 6. Save the medical orders.
 - 7. Identify the medications administered to the patient.
 - 8. Find and read the consult's note of Rosa Del Campo made by Dr Luis Rivera.
 - 9. Insert the following progress note of patient Rosa Del Campo: "Pt presents irregular HR and CHF caused by HTN".

Patient History:

Historical Exam:

- 10. Document the following:

Today, the female patient fatigued quickly, an exhibit difficulty breathing during walk, nausea, tingling in her left arm. Patient presents a history of: hypertension and diabetes type 1, which she controls with diet and insulin injections. She is allergic to Penicillin. Her medications are: Altace 10mg PO daily, 10u Novolog R S/Q, at night Levemir 40u S/Q and Avaprox 300 mg PO daily. She had asthma and she has received a blood transfusion 2 years ago. She smokes 2 cigarettes packs per week.

Her parents are alive. In her family there are members who have hypertension, heart disease, diabetes and asthma.

11. Save historical exam.

Review of Systems:

12. Consider that the patient's kidney had renal insufficiency.

13. Save review of systems.

Physical Examination:

14. Document the following:

The general appearance and the heart are normal but the abdomen reported rebound tenderness. Diagnostic Impression: Arterial Hypertension. Treatment plan: She is to be admitted to the hospital and will go to the coronary care unit (CCU).

15. Save physical examination.

4.2.2 Results

Jakob Nielsen describes usability severity ratings [Nielsen93], which relate the impact of the problem and the proportion of users who will experience the problem to the severity of the usability.

Table 4.2 Severity Scale [Nielsen93]

1: Cosmetic problem only: need not be fixed unless extra time is available on project
2: Minor usability problem: fixing this should be given low priority
3: Major usability problem: important to fix, so should be given high priority
4: Usability catastrophe: imperative to fix this before product can be released

The observations of evaluators during the heuristic evaluation are shown from table 4.3 to table 4.6 and each one has a severity scale:

Table 4.3 Usability Problems identified by evaluator 1

Observations	Severity Scale
The assigned space for showing the patient's list interfaces was too small.	2
The label Medications in the Summary Interface is not aligned with the other labels.	1
The cancel button in patient history was not working.	4
Spelling error in the label "Vital Signs".	1
The selected option smoking is changed with the text field of drugs and vice versa in the historical exam tab interface.	4
The cancel button in Historical Exam was not working.	4

Table 4.4 Usability Problems identified by evaluator 2

Observations	Severity Scale
The size of the font in the header of interface was too small and much closed.	1
The shortcuts in the laboratory and diet interface were not associated to the functionality.	3
Once added, type-selection combos do not unselected their options.	3
The selected option smoking is changed with the text field of drugs in the historical exam tab interface.	4
The cancel button in Physical Examination was not working.	4

Table 4.5 Usability Problems identified by evaluator 3

Observations	Severity Scale
The information shown at the header of the interfaces was very confusing and was difficult understanding each item.	1
Spelling error in the message of save in historical exam, review of systems and physical examination interface. It should say “.... has been saved”.	2
There was not clear feedback to submit the order.	2
Users are allowed to change tabs even if data have not being changed in the physical examination and history exam interface.	2
The selected option smoking is changed with the text field of drugs and vice versa in the historical exam tab interface.	3
The cancel button in Historical Exam was not working.	4

Table 4.6 Usability Problems identified by evaluator 4

Observations	Severity Scale
The label Medications in the Summary Interface is not aligned with the other labels.	1
The shortcuts are not clear in the laboratory and diet interfaces.	3
Once added, type-selection combos do not unselected their options.	3
There was not clear feedback to submit the order.	2
Users are allowed to change tabs even if data have not being changed in the patient history interface.	3
The selected option smoking is changed with the text field of drugs in the historical exam tab interface.	4
Misspelling in the historical exam, review of systems and physical examination interface. It should say “.... has been saved”.	1

4.2.3 Implications for redesign

The results of the heuristic evaluation were considered for the redesign of the prototype. The following changes were made to the system in response to the heuristic evaluation findings:

1. More space between each name in the patient list.
2. Label of Vital Signs in the summary interface was corrected.
3. The label of Medications in the summary interface was aligned with the other labels
4. A label was added after the data of each patient in the header
5. The data in the header has more space between data.
6. A frame with the name “Frequently Used Laboratory” was inserted. The frame contains the shortcuts for laboratory tab interface.
7. A frame with the name “Frequently Used Diets” was inserted. The frame contains the shortcuts for the diet tab interface.
8. Feedback is now provided to the user when an order is saved by returning the order tree to its initial state.
9. The problem with the check boxes and the corresponding text field in the Social History section of the Patient History Interface was corrected. The selection of a check box now activates the corresponding text field on the right.
10. A message is displayed when other tab is selected before the save action takes place.
11. A cancel button was implemented in order to clear the interface to undo changes in the Historical Exam, Review of Systems and Physical Examination.

5. RECAPITULATION AND FUTURE WORK

In this work the design of a system to support the clinical tasks of physicians with PCs and Tablet PCs was described. The development of the system required a redesign of the nurse's software in order to handle the migration of the database from a MySQL server to a MS SQL Server 2000. The software was designed in JAVA and supports a wide variety of operating systems. The interfaces were also designed taking into consideration feedback provided by physicians and nurses. The design process was accomplished by developing prototypes of the interfaces and demonstrating them to physicians and nurses. This method was instrumental in providing new functionality to the system. For example, the patient summary window (See figure 3.3) that is activated when a patient is selected from the initial list of patients was a suggestion made by physicians. This type of feature responds to the usability goal of proving the user what he/she needs, when is needed and where is need. The patient summary window is just that, exactly what the physician needs when he/she accesses the record of a patient on a daily checkup.

The design of the system was based on usability engineering principles. The main objective was to provide the most important information and most used functions at the forefront of the interface while eliminating redundant information. This is why fundamental patient information is provided at the top of the interface and remains there independently of

the tab being selected on the main window (See figure 3.3). In this way physicians always have access to the patient information when dealing with any of the electronic forms for documentation and medical orders. As it was evidenced in section 3.2. Most of the paper forms require the physicians to enter this information. With the electronic system the physicians no longer need to write this information because it is automatically provided by the system, thus saving him/her time.

Navigation of the system was minimized by providing physicians access to the different forms through a set of tabs below the header of the main interface (See figure 3.3). This provides quick access to the different forms, thus saving time. The tabs are organized in order of frequency of use with the tabs at the left being the most used ones.

Many of the electronic versions resemble very closely the original paper forms. That's the case of the Patient's History and Physical Exam forms (See figures 3.16 and 3.17). These forms provide selection boxes and text entry fields consistent with the paper forms. The only difference is that due to the display limitations these forms could not be completely displayed and, thus, need scrolling for accessing the entire form.

On the other hand orders form do not resemble their paper counter part. As it was indicated in section 3.2 in the paper Orders form orders are written as free text, one after the other, on a blank space provided. The electronic versions however, provide options for the physician (See figure 3.5), thus minimizing the use of the keyboard that is critical on a TabletPC because entering text with a stylus is awkward. In order for the physician to keep

track of the orders he/she is generating on the electronic version a tree structure is provided at the right side of the orders interface (See figure 3.5) that provides feedback when a new order is generated. As it was mentioned in section 3.2 every order needs to be acknowledge by nurses. This functionality is provided on the nursing documentation application described in [Crespo05]. An interface is provided that lists all the pending orders and provides a means for nurses to acknowledge them.

The development of the system following usability engineering principles should definitively help physicians learn to use the system and have an effective interaction with it. However, it is well known that the best way to determine the ease or difficulty in interacting with an application is by conducting usability testing with real users. This process entails selecting a group of qualified users and asking them to perform various typical tasks on the system. The users should be observed while performing the tasks. Also learnability, efficiency, errors and user satisfaction attributes should be measured. These measurement and the observations made during the test will help identify potential usability problems. Thus, conducting user testing is the next logical step to follow with the system described in this document.

Another work that should be considered for future work is the addition of an alerts and reminders application for physicians. Such application should alert the physician on abnormal laboratory and studies results as well as abnormal conditions of the patient. In addition the system should provide reminders on tasks that physicians must accomplished

such as completing the physical exam or a pending note. This system should be developed based on the same usability principles used for the designer of the Nursing alerts and reminder system described in [Perez05].

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APPENDIX

APPENDIX A

<h2>PHYSICIAN'S ORDERS</h2>				
FROM DIAGNOSIS _____ ORDER ALLERGIES _____	NAME _____ ROOM NO. (ADDRESS) _____ HOSP. NO. _____ PHYSICIAN _____			
DATE & TIME	Another brand of drug identical in form and content may be dispensed unless checked <input type="checkbox"/>	DO NOT USE THIS SHEET UNLESS A RED NUMBER SHOWS YES →	DATE & TIME	NURSE'S INITIALS

USE BALL POINT ONLY

CHART COPY

Figure A-1 Physician's Orders Form

ER _____ IP _____ ROOM# _____ SICU _____ MICU _____ OPD _____	<div style="background-color: #cccccc; width: 100px; height: 40px; margin: 0 auto;"></div> <h2 style="margin: 0;">X RAY CONSULTATION</h2>	
Patient Name: _____ <div style="display: flex; justify-content: space-between; font-size: small;"> (Last Name) (First Name) </div>		MR# _____
Sex: _____ F _____ M _____ Age: _____ Medical Insurance: _____		Date Requested: _____ Hour: _____
Exam Requested: _____ _____		
Clinical Diagnosis: _____ _____		
Physician: _____ <div style="display: flex; justify-content: space-between; font-size: small;"> (Name) (Signature) </div>		
Tech: _____ Date: _____ Hour: _____		
Patient indicates she is not pregnant. LMP: _____ Patient Signature: _____		
<div style="font-weight: bold; font-size: 1.2em; margin-bottom: 10px;">Report</div> <div style="background-color: #e0e0e0; width: 100%; height: 150px;"></div> <div style="text-align: right; margin-top: 20px;"> _____ M.D. RADIOLOGIST </div>		

Original (Medical Record) Amarillo (Radiologist) Rosa (Billing) Oro (Patient Jacket)

Figure A-2 X-Ray Orders Form





RESTRAINT ORDERS

1. Option before restraint

- ☐ Discard or exclude any organic cause.
☐ Give Sedation
☐ Allow companion ship with pt. at all time.

2. Area to be restraint

Codes

- ☐ RW Right wrist
☐ LW Left wrist

Codes

- ☐ RL Right leg
☐ LL Left leg

3. Reason for restraints

Codes

- ☐ A Aggressive pt. with high risk to injure himself or others.
☐ D Disoriented pt. with high potential risk for interrupt or avoid treatment
☐ E Entubated cardiothoracic surgery or pediatric adult (24 hours).

Code

- ☐ V Vest

Restraints may not be ordered PRN. Maximum time length is 24 hours and then they must be reordered.

Date and time ordered: _____ Duration of restraint order: _____

Physician Signature and license #: _____

RN Signature and license # (needed for telephone or verbal orders): _____

Date: _____ Time: _____

Codes: ☐ Verbal order

☐ Telephone order

☐ PRN

Reorders: If reorder is required, please date, sign and indicate type of restraints and reason as codes above.

Date	Time	Physician Signature and License #	Areas to be Restraint (Code)	Reason for Restraint (Code)	# of Hours	RN Signature and License #	Telephone or Verbal Order	Date & Time

Figure A-4 Restraint Orders Form

[illegible]

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**PATIENT HISTORY & PHYSICAL EXAM**

Patient Name _____ Record No. _____ Sex _____ Age _____

Chief Complaint _____

History of Present Illness _____

PAST HISTORY

History of Allergies or Drug Reactions (specify) _____

Medications (dosage, compliance) _____

	YES	NO		YES	NO
1. Asthma or other pulmonary diseases			8. Cancer		
2. Tuberculosis			9. Immunologic Disease		
3. Prior thrombotic or phlebitis process			10. Transfusions		
4. Bleeding tendencies			11. Toxic Habits		
5. Gastrointestinal Disease			12. Prior Surgeries		
6. Renal Disease			13. Injuries/Trauma		
7. Liver Disease			14. Pain		

Other or additional comments: _____

SOCIAL HISTORY

Habits:

Alcohol () Yes () No

Smoking () Yes () No

Drugs () Yes () No

Sedentary () Yes () No

FAMILY HISTORY

Parents:

Father () Living () Deceased/Cause if Known _____

Mother () Living () Deceased/Cause if Known _____

Disease in Family (Check all positive findings):

() Hypertension () Diabetes Mellitus () Cancer () Asthma
() Heart Disease () Mental Illness () Tuberculosis () Epilepsy

Others or additional comments: _____

2001100168

PAGE 1

Figure A-6a Patient History Form

Page 2

Patient History and Physical Exam

REVIEW OF SYSTEMS Please describe if there are positive findings	YES	NO	IF YES, SPECIFY
1. General			
2. Skin			
3. Head and Neck			
Eyes			
Nose			
Ears			
Throat			
Mouth			
Thyroid			
4. Chest			
Breast			
Heart			
Lungs			
5. Back and Spine			
6. Abdomen			
Liver			
Spleen			
Kidney			
7. Genitalia			
External			
Pelvic			
8. Rectal			
9. Extremities			
10. Lymphatic System			
Neck			
Axilla			
Groin			
11. Neurologic			
Mental Status			
Cronical Nervous Function			
Motor and Sensory Functions			
Reflexes			

Pain () Yes () No If yes, describe _____

FUNCTIONAL RISK CRITERIA

() Yes () No	Loss of Mobility	() Yes () No	Neurologic Deficit
() Yes () No	Loss of Muscular Force	() Yes () No	Amputation
() Yes () No	History of CVA	() Yes () No	Ulcer of Open Wound
() Yes () No	Musculoskeletal condition	() Yes () No	Prolonged Immobility
() YES () NO Physical Medicine & Rehabilitation Consult			

Figure A-6b Patient History Form


		
PHYSICAL EXAMINATION		Addressograph
Weight _____ lbs. Height _____ B/P _____ / _____ Temp _____ Resp _____ Pulse _____		
Check Relevant Findings		Describe Abnormalities
GENERAL APPEARANCE	<input checked="" type="checkbox"/> NORMAL - Well Development, well nourished <input type="checkbox"/> Disoriented (Place --- Time --- Person---) <input type="checkbox"/> Undernourished <input type="checkbox"/> Comatose <input type="checkbox"/> Acutely ill <input type="checkbox"/> Chronically ill <input type="checkbox"/> Non-responsive	
SKIN	<div style="display: flex; justify-content: space-between;"> <div> <input type="checkbox"/> NORMAL <input type="checkbox"/> Pale <input type="checkbox"/> Cyanotic <input type="checkbox"/> Jaundice </div> <div> <input type="checkbox"/> Ecchymoses <input type="checkbox"/> Petechiae <input type="checkbox"/> Rash <input type="checkbox"/> Other _____ </div> </div>	
HEAD AND EYES	<div style="display: flex; justify-content: space-between;"> <div> <input type="checkbox"/> NORMAL <input type="checkbox"/> Non reactive pupils <input checked="" type="checkbox"/> Cataracts <input type="checkbox"/> Unequal Pupils <input type="checkbox"/> Scleral icterus </div> <div> <input type="checkbox"/> Strabismus <input checked="" type="checkbox"/> Abnormal fundi <input checked="" type="checkbox"/> Conjunctivitis <input type="checkbox"/> Other _____ </div> </div>	
EARS	<div style="display: flex; justify-content: space-between;"> <div> <input type="checkbox"/> NORMAL <input type="checkbox"/> Otitis <input type="checkbox"/> Perforated Ear drums </div> <div> <input type="checkbox"/> Deafness <input type="checkbox"/> Otosclerosis <input type="checkbox"/> Other _____ </div> </div>	
NOSE AND THROAT	<div style="display: flex; justify-content: space-between;"> <div> <input type="checkbox"/> NORMAL <input type="checkbox"/> Nasal Discharge <input type="checkbox"/> Polyps </div> <div> <input type="checkbox"/> Deviated Septum <input type="checkbox"/> Enlarged Tonsils <input type="checkbox"/> Gum Disease </div> </div>	
NECK	<div style="display: flex; justify-content: space-between;"> <div> <input type="checkbox"/> NORMAL <input type="checkbox"/> Enlarged Thyroid <input type="checkbox"/> Neck Rigidity <input type="checkbox"/> Thyroid nodule <input type="checkbox"/> Distended Jugular Veins </div> <div> <input type="checkbox"/> Bruit <input type="checkbox"/> Displaced trachea <input type="checkbox"/> Abnormal Carotid Pulses <input type="checkbox"/> Adenopathy <input type="checkbox"/> Masses </div> </div>	
CHEST	<div style="display: flex; justify-content: space-between;"> <div> <input checked="" type="checkbox"/> NORMAL <input type="checkbox"/> Asymmetrical </div> <div> <input type="checkbox"/> Increased A-P diameter <input type="checkbox"/> Retractions </div> </div>	
BREASTS	<div style="display: flex; justify-content: space-between;"> <div> <input type="checkbox"/> NORMAL <input type="checkbox"/> Masses <input type="checkbox"/> Tenderness </div> <div> <input type="checkbox"/> Nipple Discharge <input type="checkbox"/> Nipple Retraction <input type="checkbox"/> Axillary Nodes </div> </div>	

Figure A-7a Physical Examination Form

