ABSTRACT

Team TerraMed, led by sponsor Dr. Hettinger, strived to design a more efficient, optimized version of the Computerized Physician Order Entry (CPOE) system. The current CPOE system has many flaws such as unfriendly user interfaces, cluttered design, and tedious completion of tasks. Team TerraMed implemented a system, similar to the ITunes music management system that provided efficient, clear, and user-friendly completion of tasks. Through the TerraMed CPOE system physicians and clerks will be able to order tests and medications for patients much faster and with fewer mistakes; physicians will be able to spend more time with patients.

Key Phrases
CPOE, Computerized Order Entry Form, EMR, Physicians, Electronic Medical System, Medications, Tests

Credits
- Andrew Higgins—Developed low-fidelity prototype #1, CPOE patient panel, and CPOE quick-finder panel; assisted with code debugging; assisted with user needs report, task list & questionnaires, usability report, and final project report
- Alisa Chen—Developed low-fidelity prototype #1 and CPOE help/tutorial section; coding and debugging for high-fidelity prototype; task list & questionnaires, and final project report
- Kevin Silver—Developed low-fidelity prototype #3, CPOE log in screen, and CPOE review screen
- Kristian Sooklal—Developed low-fidelity prototype #2, system transition diagram, CPOE search panel, and CPOE search algorithm; administered usability tests
- Val Kravets—Developed low-fidelity prototype #2; Team representative to sponsor Dr. Hettinger; correspondent to Dr. Shneiderman; designed CPOE main page; administered usability tests; assisted with user needs report, task list & questionnaires, usability report, and final project report

1. INTRODUCTION

1.1 Background of CPOE Systems

A Computerized Physician Order Entry (CPOE) system is an application that a medical staff utilizes to order treatment for patients. It can be either an electronic data entry form or a paper form that is usually entered into an electronic system and sent to different departments. Typically a physician fills out the CPOE form and orders either a test or medication for the patient. This means that the CPOE form usually goes from the physician to the pharmacy or laboratory, where the order is completed. The form gives a speedy and convenient way to communicate between the physician and other departments.

Prior to this system, there was mostly person-to-person communication or free-form papers where the doctors would write down their order. The problem with person-to-person communication is reliability, being dependent on whether staff remembers what the physician said. If a physician writes out their order instead of using a CPOE form, many problems still exist. Many doctors fill out a large number of orders for patients every day, and their handwriting may be illegible because of time constraints. It is also possible that they abbreviate and the person receiving the order cannot understand its meaning. Some doctors do not put the date and time of their order either, which may result in orders being placed in an untimely fashion.

CPOE solves these by having an order form that has required fields for the physician instead of just free text. In doing this, the number of errors can be significantly reduced. Also, computer entries can automatically append the date and time. This helps improve the speed and accuracy in which orders are filled out and completed. It also creates a means of backup and digital history to look up and see what has been ordered. It can reduce the time for physicians to fill out their order.

The CPOE system also has many weaknesses. The technical side must be completely flawless in order to prevent potentially deadly errors. In many hospitals, it can take years to install and implement the expensive CPOE system. The system may lead to a decrease in face-to-face communication between hospital staff, which can introduce other problems. In emergencies, filling out this form may not be the optimal solution. The CPOE system also introduces lengthy training for medical staff involved in the process.
1.2 How a CPOE System Works

As mentioned in the background of the CPOE system, a physician can either fill out a paper form or the physician logs into the hospital’s CPOE program and inputs the patient’s information. The information entered by the physician includes personal information about the patient, their past history, symptoms, diagnosis, the medical record number, and the test or medication that their physician is prescribing. Once the form is completed, it is sent to the relevant department and the order is fulfilled.

In some CPOE systems, the system is programmed to form assumptions using prior history and information in the database to make predictions or recommendations for future course of action. This can either be a great help or a nuisance to the doctor. This is due to there being extra information on the interface which the doctor may not have thought of or does not need. Other advanced implementations of CPOE systems support even more suggestions, such as drug to allergy checking, dosage monitoring, and warnings for duplicate orders.

The information is entered into a database, where the information is saved and accessed by the medical staff filling out and completing the forms. Many systems are customizable by physicians and offer real-time support. Because it is electronic, it allows for less time to be spent ordering by physicians, pharmacists, and lab technicians and more time spent with the patient or fulfilling the orders.

1.3 Benefits of a CPOE System

The adoption of a CPOE system can affect the inter-professional relationships at a hospital as well as the types of errors made in testing and medication. A CPOE system can change how tasks are assigned between physicians and nurses. It can also affect how they communicate patient information. A poorly designed CPOE system can fragment coordination of a patient’s testing and treatment plans (Niazkhani et al., 2010).

However, a well-implemented CPOE system provides physicians with means of providing electronic information and instructions for a patient to other departments or health services providers (Kuperman and Gibson, 2003). Some CPOE systems have a fully integrated EMR system that allows physicians access to patient records at the time of the order entry (Payne, 2008). Additionally, the CPOE system prevents transcription errors due to handwriting or miscommunication of notes (Kuperman and Gibson, 2003).

The CPOE system has many benefits over the traditional manner of hand-written notes and written instructions for patient care. According to an article by Dr. Kuperman and Dr. Gibson, information technology such as the CPOE system in healthcare can “decrease costs, shorten length of stay, decrease medical errors, and improve compliance” to medical standards and guidelines. They also mentioned that there are three main types of problems with the use of health services: underuse, misuse, and overuse.

According to Kuperman and Gibson, a carefully designed CPOE system can reduce underuse of health services by programming reminders to prescribe medications for coronary artery disease, a pneumococcal vaccine, or even an influenza vaccine (Kuperman and Gibson, 2003).

A CPOE system can also prevent misuse of health services. The main cause of about half of all serious medication errors were ordering errors, such as an incorrect choice of medication, an incorrect dose of the medication, or prescribing a medication that the patient was allergic to. These could be prevented by having an efficient CPOE system to verify orders with the physician (Kuperman and Gibson, 2003).

Furthermore, a CPOE system is useful for preventing abuse or overuse of health services. Excessive use of diagnostic procedures and antibiotics can be prevented through CPOE systems that present the cost of the health services, previous results, and information about the likelihood of the procedure or medication being needed (Kuperman and Gibson, 2003).

While preventing the abuse of health services is a significant advantage of using CPOE systems, there are many other possible benefits for healthcare providers. Although most CPOE systems, including this project, are concerned with inpatient systems, they can also improve efficiency and reduce medication-related problems in outpatient patients, especially when the physician, patient, provider, and pharmacy are all electronically linked. A CPOE system can help with inter-departmental relations, improving connections between the radiology, laboratory, pharmacy, and dietary departments in a hospital. Several studies also indicate that there is a correlation between having the CPOE system and having lower costs and reduced length of stays of patients (Kuperman and Gibson, 2003).

1.4 CPOE and EMR Systems

There are two major types of clinical computing systems, the Computerized Physician Order Entry (CPOE) system, and the Electronic Medical Record (EMR) system. Both systems require continuous, reliable availability and are crucial to the efficient operations of major medical centers (Payne, 2008). The major focus of a CPOE system is to provide support for a physician or practitioner to send instructions over an application to the respective departments (pharmacy, laboratory, dietary) within a medical center, or even off-site (Payne, 2008). The major focus of the EMR system is to store patient information and records within a local, stand-alone health information database that can be easily accessed, modified, or stored (Payne, 2008).

While many hospitals have both EMR and CPOE systems, few medical centers have the two systems fully integrated, which may lead to problems. For example, a patient’s record in the EMR system states that he has an adverse reaction to a medication, but the physician using the CPOE system may not have access to that record (Payne, 2008). There are both positive and negative effects associated with using an EMR system. Negative effects include higher billings to both patients and insurance companies; declines in provider
productivity due to the need to constantly update online and paper records. Positive effects include some error reduction and cost savings (Payne, 2008). The effects associated with using a CPOE system are reduced errors by physicians, cost savings due to efficient transcriptions, and more efficient and effective communication between physicians and other departments (Kuperman and Gibson, 2003). In addition to differences between the EMR system and the CPOE system (which can be integrated into one full stand-alone system), there are also many differences among CPOE systems between medical centers.

According to our mentor, Dr. Aaron Hettinger, the CPOE system varies from hospital to hospital, which is consistent with the research that our team has taken on so far. According to recent data, CPOE systems have only been implemented in 20% of all hospitals, which means that the majority of hospitals are not taking advantage of these systems.

1.5 Users

Typical users are attending physicians and residents. Physicians are responsible for diagnosing and prescribing treatment for a patient. They are the main users of this project’s CPOE system and have the greatest influence on the layout of the interface. Other users include mid-level providers, typically nurse practitioners and physician assistants. Nurses physically treat patients based on a physician’s diagnosis. Advanced nurses, known as nurse practitioners, can also makes diagnoses and prescribe medicine (NOEDB, 2007). In addition to nurse practitioners, another second level provider is a physician’s assistant. Another set of possible users are clerks. With a hybrid paper and electronic CPOE system, clerks may assist physicians by inputting their paper order into the computer system.

2. DESIGN

2.1 Approach

Initially, our team researched the design and appearance of several CPOE systems before designing our own low-fidelity prototypes. We also considered the design of the highly successful and widely used iTunes music management application because it addressed several of our usability needs, including having book-marked elements (similar to the “Favorites” songs in iTunes), having categories of elements (genres of music in iTunes), and having a feature to save sets of elements (playlists of songs in iTunes).

At the beginning of our project, our team had several ideas for creating an improved CPOE system. We initially tried using Java to create a stand-alone application that would be installed on every computer accessing the CPOE system through the Netbeans Developer toolkit. Although, the Netbeans Developer tool was helpful and intuitive at first, our team had little experience with the developer kit and the constrained time limit demanded quick development of applications. Our team decided to change our design into a website interface implementation through HTML, CSS, and JavaScript. The system is also accessible from any computer, mobile device, or other Internet-connected device.

2.2 Solution

Our solution is to have an independent CPOE system interface, able to access databases containing patients’ medical records and their previous/current treatments. The system requires the user to be an authorized physician, whose digital signature appears on their orders in the system. The main page of the system displays basic information regarding the patient in one column, a “Quick Finder” panel (containing recently ordered tests, frequently ordered tests, and saved test sets) a table containing all of the tests and medications the hospital may order, and a table containing the list of selected tests or medications for the patient. The system allows users to order tests individually and as a set, to save a set of selected tests for future reference, to search through both tables for a test based on multiple parameters, to access a help page, to authenticate an order before submitting it. The system displays a confirmation page upon successful signing of an order. The system also allows the user to log out at any time, or to select a new patient at any time on the main page or the confirmation page.

2.3 Transition Diagram

![Transition Diagram](image)

Fig. 2.1 – transition diagram

This transition diagram shows the process flow of the system from start to end.
2.4 Login Page

The login page has is the first screen that is displayed upon initializing the system. The login fields take in a user name and a password of a physician, with the option to clear all fields or to “Login”. When clicked, the “Login” calls a function to compare the login information to a database of physicians’ accounts.

2.5 Main Page

Fig. 2.2 – an overview of the main page of the CPOE system.

Fig 2.3 - “Commonly Used” test sets feature of the CPOE system.

Fig. 2.4 - “Recently Used” test sets feature of the CPOE system.

Fig. 2.5 - “Saved Test Sets” feature of the CPOE system.

Fig. 2.6 - Search functionality of the CPOE system.

Fig. 2.7 - Selection of a test, “Left Cornea Scan” on the main page of the CPOE System.
The main page of the CPOE system provides all of the functionality of the system. The CPOE system offers several quick finding features, such as “Recently Ordered”, “Commonly Used”, and “Saved” test sets. The CPOE system also provides the patient’s information as a measure of error prevention against ordering tests for the wrong patient and against ordering medications they are allergic to. The left table on the main page contains all of the CPOE tests and allows for individual selection of as many tests as the user needs. The right table on the main page displays all of the selected tests for the order. The tables in the CPOE system are both searchable, which allows physicians to quickly find a test, select the test, and verify that it exists in the “Ordered Tests” table. Additionally, the main page provides support through the help page and allows the user to logout. Finally, the main page requests authentication before the user completes the order, adding a level of security to the process.

2.6 Confirmation Page

The confirmation page has a layout similar to the main page, displaying a confirmation message with an order identification number and a date and time, which can be used for future reference if an order were to be lost in the system or not delivered on time by the recipient of the order. Additionally, the confirmation page allows the user to cancel a sent order, which can help with error prevention (one of the original goals of the system), by allowing an immediate cancellation of an unnecessary test. This is possible because lab tests are not done immediately after the order is placed in the system, so there time to cancel the test. The confirmation page allows the user to order new tests on a different patient, to seek help for using the interface, or to log out of the system.

2.7 Help

The help page provides a high level description of the features of the CPOE system. The help page can be accessed by clicking the “Help” button on the top right corner of the main CPOE screen. First, to select a patient, click on the “Select New Patient” button on the top left corner of the screen. Then, click on the Allergies panel in the patient information column in order to view the patient’s allergies. In order to hide or show the patient’s image, click on the hide/show button. Then, in order to select a test, click on the “Select” button next to a test in the first table. Alternatively, click on the “Select” for the Quick Finder panel to select tests. To remove a test from the “Ordered Tests” table, click on the “Remove” button next to the test. To complete the order, click on the “Sign” button and provide the valid credentials to the system. Finally, proceed to the confirmation page and either logout or click on the “Select New Patient” button to finish the process.

3. DEVELOPMENT PROCESS

As a medical order entry form, the interface for the CPOE system is a lifetime system for industrial and commercial use by physician/primary caretakers, nurses, and clerks/secretaries. Operator training time is lengthy and expensive and user retention is maintained through frequent use of the system. Ease of learning, speed of performance, and minimizing errors is critical to designing a useful CPOE system. Being used by professionals, there is some margin for tradeoffs in subjective satisfaction. The goal for the interface is to make the process of ordering tests easier and more efficient for physicians and primary caretakers. Our team made sure to keep these concepts in mind when designing the low-fidelity prototypes for the CPOE system.

Team TerraMed created three intuitive low-fidelity prototypes to provide rudimentary levels of comprehension for the layout, functionality, and organization of the envisioned CPOE system. Fast access to the most commonly ordered tests, while still providing access to the other thousands of tests available, was the central focus of the CPOE prototype designs. The flow diagram represented in Fig. 4.1 demonstrates the functional process that all of the designs were based around.
The first prototype, demonstrated in Fig. 4.1, was largely influenced by iTunes music management software. One of the primary goals of this design was to provide the entire functionality of the CPOE system in one view that encompasses patient information, test selection, test order preview and confirmation, as well as an optional side pane that allows for fast ordering of frequently used tests. This design would allow orders to be made from one screen that provides as much information as possible while allowing simple actions to perform at each stage of order entry.

The second prototype design, shown in Fig. 4.2, was developed around a direct manipulation format to allow for easier learning, handling, and retention by beginner and novice users. The unique features that set this design apart from the current CPOE system were the “Favorites” tab, the “Most Recent” tab, and the “Top 25” tab. The main advantage of these three tabs would be that users could quickly and easily access tests that are frequently used or that are important for the physician (as determined by physician’s selection of favored elements). This optimization supports user’s internal locus of control by allowing them to quickly access important and highly used tests with ease. Also, by having a quick access system, the short-term memory load of the user would be greatly reduced because they are able to access the necessary test much faster rather than go through several menus and screens to get to the proper test. The CPOE system would still allow users to access the thousands of other tests and medications that are available.

The third prototype design of this user interface, depicted in Fig. 4.3, was based upon popular interfaces such as Amazon and iTunes. The way this interface incorporates a menu-based search style was the most important tool of the design. It is very difficult to narrow down a text based search that includes thousands of tests and medications; therefore, menus will prevail where text based searches are ineffective. Our team used principles and elements from all of these low-fidelity prototypes in developing the high fidelity prototype. After discussing the low fidelity prototype with our mentor, our team brainstormed elements of each of the prototypes that we thought were effective and useful. After brainstorming a large list of elements and principles, our team merged all the aspects of the list into a final high fidelity prototype that was largely based around the first prototype layout. The high fidelity prototype was designed to include elements such as a gray scale color scheme, column-based layout, help button, quickfinder panel functionality, patient information display, separate search and ordered tests/medications panels, font style, and many others.

After designing and refining the high fidelity prototype, our created usability testing reports. These reports consisted of a pre-test questionnaire, task list to be completed by test subjects, and post-test questionnaire. The following Figures represent the pre-test questionnaire, task list, and post-test questionnaire.
Dr. Aaron Hettinger is our team’s primary sponsor and expert advisor. Dr. Hettinger is an Emergency Room Physician in a Washington, DC hospital; he has also done extensive research on the usability of computerized systems in a medical environment. On Friday November 11th Dr. Hettinger met with our team in College Park to perform an initial usability test. During this session we were able to gauge the effectiveness of our design and test cases, and with Dr. Hettinger’s suggestions and feedback we were able to make some modifications for the second round of usability testing.

In general Dr. Hettinger was impressed with the work we had done furnishing a prototype in such a limited time and with a lack of prior experience with computerized medical technology. One of the first things that he noted about our test setup was that we provided a mouse for use with the testing laptop. In a deployed CPOE system the interface would be used with a mouse, so while a laptop track pad would have given us some useful feedback having an actual mouse was a great advantage.

Dr. Hettinger had several ideas for minor modifications that could be made to our interface for future rounds of testing. One of the main points he made was that there is a lack of flow for mouse movement. In the version of the interface tested on Dr. Hettinger the “order” and “remove” buttons for each test were located on the opposite side of the table from the search box, which required a lot of extra mouse movement and was mildly disorienting. A suggestion proposed for this was to align many of the action buttons vertically with the search box. This included moving the “add” and “remove” buttons to the leftmost column of the test selection table and placing the “sign” order button directly below that. This wound up slightly modified in our second version as the relative positioning of the search table and selected tests table.

During the course of our conversation with Dr. Hettinger he gave us several general pointers to keep in mind while making modifications to our interface. The principle from Edward Tufte of “don’t waste ink” was very important. Because of the amount of information that we are displaying on a single screen it is very important to minimize distractions in the interface to make it easier for novice users to become advanced users. He also made a point of noting how important a layout can be when it is used in the medical field. “A layout can have a great impact on safety; e.g. a lot of the time doctors don’t look at the patient information after a patient is selected, leading to ordering tests for the wrong patient; having a picture in immediate view can help with that.” Because of this advice we decided to move the patient picture to the top of the Patient Information panel so that it would be more obvious to physicians and clerks in a hurry.

Our team completed ten interviews with users ranging from physicians to clerks. This initial round of usability testing involving only Dr. Hettinger and members of our team gave us the opportunity to iterate our design between usability test phases. After making modifications to our interface using Dr. Hettinger’s feedback as a guideline we were able to perform second round usability testing on a wider range of participants.

Andrew is a 21 year old male college student who is a computer science and physics major and utilizes the computer 40-50 hours per week. Andrew stated that he
The first test subject, Lindsay, is a physician. Lindsay had problems with the table in the middle of the screen (the search table), because it was unclear what the purpose of the table was at first. Additionally, the “Quick Finder” panel was in the middle of the page, which was somewhat different from the expected iTunes layout. Additionally, Lindsay wanted the system to show explicitly the ability to search by category and the ability to search by name. Furthermore, Lindsay wanted to know how to undo an incorrectly deleted test, such as by having an undo button for the whole table/page. Finally, Lindsay wanted to know which physician was signed in at all times (especially on the authentication dialogue), just in case two different physicians use the same computer. Overall, Lindsay found the tasks themselves to be relatively easy, with most of the feedback being related to the system, not the task.

The second test subject, Robert, is a physician. Robert had an issue with the word choice of “Select” vs. “Add” a test, because the user may not be sure if the word “Select” is going to actually add the test to the order. Additionally, Robert took a second or two extra to find the “Sign” button. For the second task, Robert was unsure of what specific fields the search bar was searching on. For the third task, Robert also pointed out that when ordering a set of tests twice, this would create five error dialogues, which is too many, and the ordering of one set of tests twice should only bring up one error dialogue. Similarly, Robert pointed out that the test set should stay as a group within the ordered test panel, so that if the user wanted to remove a set of 20 tests from the “Ordered Table”, it should only take on click to remove the whole tests as opposed to 20 individual clicks. Finally, Robert noted that there should be a “Pending Orders” section of the confirmation page in order to show what orders had recently been processed. Overall, Robert also found the tasks to be easy to complete.

The third test subject, Erica, is an administrative coordinator with 1 year of professional experience. While she had never used a CPOE system before, she had significant experience with the iTunes application. The fourth test subject, Terry, has 15 years of experience as a paramedic and 11 years of experience as a physician and was the director of the Human Factors team. The fifth test subject, Vicci, has 21 years of experience as a Human Factors Engineer, but had never used a CPOE system before. All three subjects provided feedback together after they completed the tasks. The subjects noted that the name of the patient was not prominent. Also, the physicians noted that the age of the patient took up too much space, since they did not see the need for the “months” of the patient’s age. Additionally, the subjects said that the “Recently Used” was hard to find. Furthermore, the subjects noted that the “Sign” button should have been more prominent. The users also wanted a “Back” button or some navigation functionality between the confirmation page and “mainCPOE.html”. Also, the subjects noted that some fields required the click of a mouse instead of being tabbed too or the cursor being placed there automatically. Furthermore, the users wanted the the “Enter” button to be able to work when signing the page. Finally, subjects noted that when there is a test set with a single test such as “D-Dimer” under “Recently Used”, then this should be condensed to take up less space. Overall, the users found the task to be easy and straightforward.
After conducting the usability testing, each subject completed a post-test questionnaire. There were eight central questions, with each question requiring a user rating ranging from one to seven. A rating value of one would indicate a poor, unsatisfactory opinion or difficulty with assignments, while a seven would indicate an excellent, satisfactory opinion or simple ease to complete tasks.

![Post Test Questionnaire](image)

**Fig 4.6 – Results from Post-Test Questionnaire**

On average it appeared that the CPOE system received the highest ratings on its ease of learning and font style. The lowest ratings were received on the color setup and visual presentation. Some important contents from the post-test questionnaire that reflect the user’s opinions of the system are stated below:

- “Couldn't find the sign button at first because I didn’t realize I needed to scroll down.”
- “The things that needed to be expanded should have a right arrow not a down arrow.”
- “The layout was kind of boring-consider colors a bit more aesthetically pleasing colors.”
- “Move sign up so it is visible without scrolling down”
- “Some instructions would be helpful.”
- “Resize sign”
- “Awesome”
- Back button from confirmation page to mainCPOE.html
- Navigation functionality (see previous comment)
- Password authentication box (encrypted)
- Display the name of the physician that is logged in when asking for the password (in case multiple physicians are using the system, that way the physician currently using the system knows that he or she is logged in as their self, and not as someone else)

Based on the results of the post-test questionnaire, it is evident that the color setup and visual presentation were the main factors that required revision. The following is a breakdown of the specific aspects of the CPOE system that were identified as problems and a description on the means for fixing the issues.

Identifying problems (1-5 points in terms of importance (5 is most important) and effort to repair (5 is most time consuming)) :

- Using the key comments made by users we can clearly see that the “sign” button in our interface needs to be revamped. This also brings about some resizing issues of the entire layout. This is clearly our most important issue because the user must be able to easily and quickly find and utilize the sign and submit. This issue is given a 5 in importance and a 4 in time consuming. This can be fixed by adjusting the size of the main CPOE system so that the sign button fits on the screen without requiring users to scroll down.
- Our next issue is that the down arrow should be a right arrow in the “quickfinder”. This is only a minor issue but will definitely help in clarity that the “quickfinder” does have the ability to expand. This issue may be confusing to some users so it has an importance of 2, but easily fixed, so an effort to repair of 1.
- Our last issue is in our visual layout. This is not important for the usability since there was no problem with confusing colors, but instead on its appeal. This can have a subjective importance but it would probably be around a 3 or 4 and an effort to repair a 2 or 3, depending on how significant the changes are.

4. CONCLUSIONS

After the feedback from the usability tests, the high-fidelity prototype was refined further so that every panel would be visible without scrolling. The heights of the header and footer panels were reduced. The columns of the main CPOE screen were set to equal height, leaving the “Sign” button visible at the button without scrolling required. JavaScript was used to simulate a liquid layout, adjusting width for the columns with lists of test as the window is re-sized.

Although a few fellow developers suggested the “Select” buttons in the test selection panel be replaced by check boxes, this was considered confusing with the selected tests panel next to it. Its “Cancel” buttons would also have needed to be replaced by check boxes for consistency. It was difficult to determine whether the boxes ought to be checked to show a test had been ordered and unchecked to cancel it, or if vice versa was a more natural indicator.

Future extensions for this interface include implementing the Select Patient screen,

Other features that need to be refined:

- consolidating warning messages (e.g., getting five separate messages when accidentally double-clicking on an order set)
- checking for allergies (e.g., to chemical dyes used in imaging)
- allowing pressing the Enter key to trigger the “Sign” button
• encrypting the password field in the dialog box after signing
• implementing a “Back” button from the Confirmation page to the Main page
• graying out rows of selected tests under the test selection panel
• consistently using the same style arrow icons throughout the design
• toggling direction of the arrow icons on the Quickfinder Panel when clicked
• changing the color of arrow icons on hover
• adjusting the spacing with the arrow icons in the table so that less space is wasted

There are a few functional and aesthetic recommendations for future developers of this CPOE system. Regarding the former, the current prototype is static—it is not connected to a hospital database. Much functionality requires databases of information. Proper authentication of users would require a list of authorized users. Sending the tests to the appropriate labs and the pharmacy was not possible with this standalone CPOE interface.

Another desirable feature would be having an image modeling a person appear when specifying a region for an imaging test. This would be useful in helping prevent errors, such as ordering imaging tests for the opposite side of the body.

Also, while some CPOE systems vary in scope, such as separate systems for tests and medication; greater interdepartmental communication would be possible with a single system. Thus, including medications would be a natural extension to this CPOE system. Including medications would also allow us to implement warnings by checking against the list of patient allergies.

Regarding the appearance of the system, a good layout for wide screens or dual monitors has not been researched. This project has also focused on PCs rather than tablets or mobile phones. The dimensions and method of input on these devices would require more significant changes to the design.

5. ACKNOWLEDGMENTS

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6. ANNOTATED REFERENCES

This scientific article from a journal that was found on a website was helpful in determining the benefits and costs of the CPOE system. Specifically, the article used several studies to show how the CPOE system had improved the quality of healthcare, and the article gave several reasons for why and how the CPOE is used at medical facilities.

The abstract of this paper gave the objective of the study as “assess[ing] the affects of a CPOE system on inter-professional workflow in the medication process,” and concluded there were both advantages and disadvantages in the changes in the workflow between physicians, nurses, and pharmacists due to the CPOE system.

Aimed at those interested in entering the medical field, the article briefly explains the differences and similarities between nurses and doctors.

This book gave an overview of “Clinical computing”, which included both the EMR and CPOE systems and was useful in determining some (not all) of the differences between the two.