Comparing Computerized Physician Order Entry Usability between Expert and Novice Primary Care Physicians

Martina A. Clarke[1], Jeffery L. Belden[2] and Min Soon Kim[1, 3]
[1]University of Missouri Informatics Institute, University of Missouri, Columbia, MO, U.S.A.
[2]Department of Family and Community Medicine, University of Missouri, Columbia, MO, U.S.A.
[3]Department of Health Management and Informatics, University of Missouri, Columbia, MO, U.S.A.

Keywords: Electronic Health Record, Usability, Primary Care.

Abstract: *Objectives*: To examine usability gaps between expert and novice primary care physicians when using computerized provider order entry (CPOE). *Methods*: To analyze usability gaps between ten novice and seven expert physicians, using the triangular method approach, usability tests involving video analysis were conducted. *Results*: While most novice physicians completed tasks less proficiently, and provided a lower System Usability Scale (SUS) score than expert physicians, the result of 'percent task success rate' ($t(8) = 2.31$, $p=0.98$) was not significant for both physician groups on all five tasks. Seven common and four unique usability issues were identified between the two physician groups. Three themes emerged during analysis: user interface issues, ambiguous terminologies, and training and education issues. *Discussion and Conclusion*: This study identified varying usability issues for users of CPOE with different expertise. Two additional iterations of the usability data collections are undergoing to uncover comprehensive usability issues and measure the learnability.

1 INTRODUCTION

The use of health information technology (HIT) in clinical practice is increasing rapidly and more physicians are using computerized provider order entry (CPOE) because of the financial incentives promised by Medicare and Medicaid. CPOEs are defined as a clinician's use of computer assistance to prescribe medication orders from an electronic device. There is some evidence that the use of CPOE may cause unintended consequences, such as increase in clinician work, undesirable workflow issues, and generation of new kinds of errors (Berger and Kichak, 2004, Ash et al., 2003). Poor usability of CPOEs has been shown as one of the major factors that leads to issues, such as reduced efficiency, decreased quality of patient care, and frustrated clinicians (Khajouei and Jaspers, 2010, Chan et al., 2011, Kjeldskov et al., 2010, Neinstein and Cucina, 2011). Usability is defined in this study as how well users can operate a system to effectively and efficiently achieve particular goals with satisfaction (1998). With the healthcare reform underway, the shortage of primary care providers, caused by an increase in patients, has greatly reduced physicians' time with patients (2011a). Allowing physicians to quickly complete required tasks within the CPOE may relieve a part of the time constraints they experience while treating patients.

The overall objective of this pilot study is to compare performances and determine unique and common usability problems between expert and novice physicians. Usability gap is being defined as challenges that users experience when using a system to complete specific tasks. Our hypothesis is that expert physicians will encounter less usability issues and be more efficient than novice physicians when using the CPOE. If there is no significant difference between novice and expert physicians then the usability issues identified is not based on novice physicians' inexperience with the system but that there is room for improvement in the current design of the CPOE.

2 METHOD

2.1 Study Design

To identify usability gaps in CPOE systems between

Clarke M., Belden J. and Kim M..
Comparing Computerized Physician Order Entry Usability between Expert and Novice Primary Care Physicians.
DOI: 10.5220/0005188503040311
In *Proceedings of the International Conference on Health Informatics* (HEALTHINF-2015), pages 304-311
ISBN: 978-989-758-068-0

expert and novice physicians, data collection was conducted through standard usability tests using video analysis (Morae®, TechSmith, Okemos, MI), as eleven family medicine, four internal medicine first year resident physicians, and one attending physician completed five artificial, scenarios-based tasks in a laboratory setting. To examine the usability gaps between the novice and expert physicians, quantitative analyses were conducted that included four sets of performance measures, system usability scale (SUS) measurement, and subtask analysis. The usability test lasted for about 20 minutes and was conducted on a 15 inch laptop using Windows 7.

To maintain consistency and minimize unwanted distractions, the room consisted of the participant and the facilitator. The session began with the participant being reminded that their participation in this study was completely voluntary and they had the right to stop the session at any time. The participant was then instructed to read the printed instructions, containing a scenario and five tasks, from a binder next to the laptop. The facilitator sat near the participant to be available for any questions while supervising the session. Participants completed the tasks on their own and the facilitator intervened only if technical issues arose. This pilot study was reviewed and approved by the University of Missouri Health Sciences Institutional Review Board.

2.2 Organizational Setting

University of Missouri Health System (UMHS) is a 536 bed, tertiary care academic medical hospital located in Columbia, Missouri. UMHS employs more than 70 primary care physicians at UMHS clinics throughout central Missouri and had an estimated 553,300 clinic visits in 2012. The Department of Family and Community Medicine (FCM) manages six clinics and has over 100,000 patient visits at these clinics, while the Department of Internal Medicine (IM) manages two clinics (2011b). The Healthcare Information and Management Systems Society (HIMSS), which is a non-profit organization that tracks how hospitals are adopting electronic medical record (EMR) application, has awarded UMHS with Stage 7 of the EMR Adoption Model (2013b, 2011c), which means the hospital uses electronic patient charts, incorporates data warehousing to analyze clinical data, and share data electronically with authorized health care entities (2011c).

Evaluating usability of a fully implemented CPOE system within one of the most wired health care setting makes the goal of this study achievable.

2.3 Participants

Currently there is no evidence-based way to measure EHR experience. According to the discussion with an experienced physician champion (JLB) and two chief residents from both participating departments (FCM, IM), clinical training level and experience with CPOE was used to differentiate novice physicians from expert physicians. First year residents were categorized as novice users and residents with over one year experience with current CPOE were considered expert physicians. Based on an expert's experience, being proficient in one EHR does not make a user proficient in all EHRs. First year residents as were selected as novice physicians because they experience more clinical and technical burdens than any other resident physician group.

The sample of first year resident physicians (residents) was selected from UMHS FCM and IM because, as primary care residents, clinical roles and responsibilities are comparable. One team member (JLB), a family medicine physician, had valuable connections with these two provider groups. The convenience sampling method was used when selecting participants (Battaglia, 2008) and data collection was from November 12, 2013 to December 19, 2013.Based on a review of the literature, ten participants is acceptable in explorative usability studies to identify salient usability issues (Barnum, 2003, Kim et al., 2012). Residents were compensated for their participation.

2.4 Scenario and Tasks

In this study, the case presented to the residents was a 'scheduled follow up visit after a hospitalization for pneumonia.' Five tasks commonly performed by both expert and novice primary physicians, were conceptualized for the participants to complete. The tasks completed were also a part of the EHR training residents participated in at the start of their residency to make this evaluation practical and would not include complex tasks not covered in training. The tasks had a clear objective that physicians were able to follow without excessive clinical cognitive challenges or ambiguity, which was not one of the study's goals. Tasks completed were:

Task 1: Place order for chest X-ray
Task 2: Place order for Basic Metabolic Panel (BMP)
Task 3: Change a medication
Task 4: Add a medication to your favorites list
Task 5: Renew one of the existing medications

2.5 Data Analysis

The overall objective of this study was to determine usability gaps in CPOE systems between expert and novice physicians. Morae Recorder was used to capture audio, video, on-screen activity, and inputs from the keyboard and mouse. Morae Manager was then used to analyze the recorded sessions by calculating performance measures and with markers, code difficulties, errors, and complete the subtask analysis. Approximately 1.5 hours of video analysis were required per recorded session of 20 minutes. The first step in analysis was to review the recorded session and label any tasks that were not marked during data collection. The second step was to subdivide each of the five tasks into smaller tasks in order to calculate the task success rate and identify subtle usability challenges that may have otherwise been missed. The t-test was used to compare performance measures. Pearson's correlation was used to determine whether there is a relationship among SUS and performance measures.

2.6 Sub-task Analysis

Each physician may complete the same task in various ways, which is why sub tasks are included in the usability analysis to understand how participants interact with the system on a more granular level. Each video recorded session was reviewed and individual tasks were broken down into smaller sub-tasks, that were examined and compared across the participants and tasks to identify subtle usability challenges in the form of errors, workflow, and navigation pattern variability that otherwise would have been overlooked. For example, when physicians complete task 1, "Place order for chest X-ray in one month" the desired subtasks would be:

1. Go to CPOE
2. Find Chest X-ray
3. Click Done
4. Enter Presenting symptom: type 'cough, pneumonia follow-up'
5. Enter Requested time frame: select '4 weeks'
6. Enter Requested Start Date/Time: use calendar to get to <date one month away>
7. Add Supervising Physician: 'Belden'
8. Click 'Sign'

To analyze our data, thematic analysis was utilized to report our usability findings (Braun and Clarke, 2006). Some themes identified in this study were adopted from a study by Walji et al (Walji et al., 2013) but were modified to include implications to clinical workflow. Usability issues were recorded and an example was included to explain where the issue took place. An attending physician and experiences usability expert (JLB) was included in the discussion of implications on clinical practice or workflow and then contributed suggestions for improvement.

2.7 Performance Measures

Four performance measures were used to analyze user performance as follows:

1. Percent task success rate, which was computed by determining the percentage of subtasks that participants completed successfully without any errors.
2. Time-on-task which measures the duration of time each participant took to complete a given task, beginning when participants clicks 'start task' to when 'end task' is clicked.
3. Mouse clicks which measures the counts of clicks on the mouse when completing a given task.
4. Mouse movement computes in pixels the length of the navigation path to complete a given task.

For time on task, a lower value signifies higher performances. For mouse clicks and mouse movements, lower values signify higher performance. Higher values may depict that the participant had difficulties with the system.

2.8 System Usability Scale

To supplement the performance measures, each participant completed a system usability scale (SUS), a ten-item Likert scale that is an overall, subjective assessment of a system. SUS yields a single number that illustrate a composite measure of the overall usability of the system under analysis. SUS yields a score from 0 to 100, with 100 being a perfect score (Brooke, 1996). Score of 0 to 50 is considered not acceptable, 50 to 62 is considered low marginal, 63 to 70 is considered high marginal, 70 to 100 was considered acceptable (Bangor et al., 2009).

3 RESULTS

3.1 Participants

Seven novice physicians were from FCM and three were from the IM at UMHS. The age of novice physicians ranged from 27 to 31 and the mean age was 28 years. Four (40%) novice physicians had no other experience with an EHR other than the EHR at

UMHS, two (20%) have less than 3 months experience, one (10%) had 7 months to one year experience, and three (30%) had over 2 years' experience with an EHR other than current CPOE. Six family medicine and one internal medicine expert physicians participated in the study. Two expert physicians did not provide information on their date of birth and EHR experience and were not included in the calculation of age range, mean age, and EHR experience. The age of expert physicians ranged from 30 to 62 and the mean age was 37 years. One (14%) expert physician had no other experience with an EHR other than the EHR at UMHS, one (14%) had 7 months to one year experience, and three (43%) had over 2 years' experience with an EHR other than current CPOE.

3.2 Performance Measures

Geometric mean values (Cordes, 1993) of percent task success rates (50%, expert group vs. 50%, novice group), time on task (39s, expert group vs. 45s, novice group), mouse clicks (9 clicks, expert group vs. 10 clicks), and mouse movements (8,802 pixels, expert group vs. 8,146 pixels, novice group) of five tasks were compared between the expert and novice physicians across two rounds. There was no significant difference in percent task success rate ($t(8) = 2.31$, $p=0.98$), time on task $t(8) = 2.31$, $p=0.59$), mouse clicks ($t(8) = 2.31$, $p=0.64$), and mouse movement ($t(8) = 2.31$, $p=0.70$) which means we fail to reject the null hypothesis.

To determine whether novice physicians experience with another CPOE affected their performance measures in this study, geometric mean values of novice physicians with over 1 year previous experience with an EHR were compared with novice physicians with less than 1 year experience. There was no significant difference in the task success rate (47%, novices > 1 year previous experience vs. 51%, novices < 1 year experience; ($t(8) = 2.31$, $p = 0.91$), time on task (33, novices > 1 year previous experience vs. 52, novices < 1 year experience; $t(8) = 2.31$, $p = 0.62$), mouse clicks (6 clicks, novice physicians with over 1 year previous experience vs. 12 clicks, novice physicians with less than 1 year experience; $t(8) = 2.31$, $p = 0.81$), and mouse movements (3,445 pixels, novice physicians with over 1 year previous experience vs. 11779 pixels, novice physicians with less than 1 year experience; ($t(8) = 2.31$, $p=0.57$) between the novice physicians with over 1 year previous experience and novice physicians with less than 1 year experience.

3.3 System Usability Scale

All ten novice physicians and six out of seven expert physicians completed the SUS after the usability test. The SUS demonstrated that novice physicians rated the system usability at a mean of 68 (high marginal) and experts rated it at a mean of 70 (acceptable). Two novice physicians and one expert physician gave a score below 50 (not acceptable). This result may indicate that novice and expert users of the CPOE still might not accept the product regardless of proficiency or length of time using the system. The Pearson correlation coefficient between task success rate, the most objective performance measure, and participants' individual SUS score highlights that participants task success may have almost no relation to how user-friendly participants regarded the CPOE system ($r=0.09$).

3.4 Usability Issues Identified through Sub Task Analysis

Sub-task analysis was also instrumental in identifying multiple usability concerns. There were seven common and four unique usability issues identified between the two physician groups (Table 1). Three themes emerged during analysis: user interface issues, ambiguous terminologies, and training and education issues. The majority of usability issues may have an impact on the time both novice and expert physicians would spend completing orders instead of with their patients because of user interface issues and ambiguous terms. Training and educational issues also arose for both novice and expert physicians, which could be alleviated by improving training on these specific issues.

4 DISCUSSION

4.1 User Interface Usability Issues

Poor user interface design of CPOEs may cause usability issues and increase the risk of medical errors if important information is not presented in an effective manner (Khajouei and Jaspers, 2010). Poor interface design may create difficulties for physicians, especially novice physicians, to find certain information, which may lead to unsuccessful searches further frustrating physicians (Horsky et al., 2004, Zhan et al., 2006). Many adverse drug events for example resulted from poor CPOE interface design rather than from human error (Khajouei and Jaspers, 2010, Koppel et al., 2005, Peute and Jaspers,

Table 1: Usability issues identified from sub task analysis, their implications on practice and suggestions.

Usability Issue and Example	Implication on clinical practice/workflow	Suggestion
USER INTERFACE ISSUES		
Inconsistent ordering of command/action buttons The location of buttons 'Orders for Signature', 'Sign', and 'Done' varied depending on the window that is being used.	Orders may not get completed. Users ignore the alert warning that 'some tasks are not complete. Are you sure you want to leave this chart?'	Do card sort /user mental mapping process to see what terms users find more natural.
Illogical ordering of lists Medication list cannot be alphabetized when imported into a patients visit note.	Non-alphabetized lists frustrate physicians when they cannot figure out how to sort the medication list.	Import medication list to visit note in the order that physicians had them sorted in the CPOE.
Unclear menu options To change a medication you either use 'Renew', 'Cancel/DC', or 'Cancel/Reorder'.	Physicians make the wrong choices, take longer to complete the task because language is confusing.	Test the language in the menus with actual users in a group session to the best terms to use.
Hiding functionalities one layer down Physicians cannot add medication to a favorite list from the medication list in a patient's visit note. Adding a med to favorites can only be done in the order detail view, not in the main medication list view.	Physicians are less like to build a favorite menu therefore they cannot take advantage of this functionality.	Allow the option to add a medication favorite by right clicking the main medication list.
Extra mouse clicks To see the changes that were made in the CPOE, the 'Refresh' button needs to be clicked for the changes to appear.	Physicians may not notice there is new information and act without the new piece of information. Confused and frustrated because they expect the results to automatically update.	The 'Refresh' button improves performance by reducing frequent queries to the database. Users need to be trained to remember to click 'Refresh.'
AMBIGUOUS TERMINOLOGIES		
Multiple fields with the same functionality There is no clear difference between the drop down labeled 'Requested Start Date', the drop down labeled 'Requested Time Frame', and the radio button labeled 'Future Order.'	Future labs may not be ordered properly so labs may not be completed at the right time. Patients may have to get the test redone which brings additional cost to the patient.	Remove fields that may be duplicates.
Search results do not match users' expectations A search for BMP, blood tests that provides information about patient's body's metabolism (MedlinePlus, 2013), retrieves multiple versions of same test with different order detail completion.	Takes extra effort for physicians to complete orders.	Pare down menu options. Remove unnecessary option or simplify menu choices.
Vague wording for alerts A novice physician tried to order a chest X-ray but continuously received an error: 'Radiology orders should be placed following downtime procedures during 2200 and 0000.'	Physician becomes frustrated and spends time trying to decipher the meaning of the alert.	Create more meaningful alerts where the physician can clearly understand the next steps.
Unexpected terms in date fields An expert physician did not create a future order for one month because the terminology used was 'four weeks' and the users kept searching for 'one month.'	It is confusing and takes doctors a little longer to complete orders.	Add an additional choice that says '1 month.'
TRAINING AND EDUCATION		
Extra steps to complete multiple orders Novice physicians did not know how to create two orders at the same time. One novice physician mentioned that there was probably a way to order them both but did not know how.	Take more steps to complete multiple orders.	Make the new orders being processed more visible to the user.
Entering the date in the wrong field An expert physician put the future date in the comments field to place a future lab order instead of using the structured date entry field.	If the date is not inputted properly, the labs may be completed at the wrong time.	Educate physicians on best practices for inputting future orders.

2007). Inconsistent ordering of command/action buttons may cause a medication being prescribed to not be completed because the physician may click on the wrong button and cancel the order instead of ordering the medication. Physicians have very limited time during clinical encounters. During our study, physicians did not have the option to reorder the medication list alphabetically. They also faced difficulty when changing a medication and spent more time than necessary adding a medication to a favorites list. Usability issues, such as, illogical order of terms and unclear options for specified tasks, affects the limited time physicians have to see patients and may negatively affect clinical workflow. CPOE interface designs that do not integrate with physicians' behavior and decision making processes, may cause inefficient workflow (Khajouei and Jaspers, 2010). A study by Walji et al., evaluating the usability of a dentistry EHR interface, also detected several challenges from poor user interface similar to this study, such as illogical ordering of terms and time consuming processes to complete simple tasks (Walji et al., 2013).

4.2 Ambiguous Terminology

Ambiguous terminologies can create errors when physicians are trying to complete a task in the CPOE. For example, one novice physician was not able to order a chest X-ray for task 1 and did not understand the meaning of the alert presented before him. If a physician received this alert during clinical workflow, the physician would not be able to order the chest X-ray in a timely manner and may have to return to the order later and instead, may forget to re-order the X-ray. He may also miss a critical diagnosis that could have been identified from the patient receiving the X-ray. A study by Yui et al., evaluating the satisfaction of physicians with the CPOE system, also found usability issues where keyword searches did not produce expected results. Physicians were not able to locate a common test, 'urine analysis', by typing 'urine' (Yui et al., 2012).

4.3 Training and Education Issues

According to a study by Ghahramani et al., evaluating CPOE's impact on workplace stress and job performance, stated that training of clinicians' CPOE use should start during medical or nursing schools to increase familiarity and to improve patient safety and efficiency (Ghahramani et al., 2009). In this study, no statistically significant differences were found between expert and novice physicians' performance measures but novice physicians expressed slightly less satisfaction with the CPOE than expert physicians, which disproves our hypothesis. A study done by Kim et al. (Kim et al., 2012), analyzing usability gaps between expert and novice emergency department nurses, found similar results where no substantial difference was found in task success rate on EHR use between two nurse groups with varying expertise. The results from our study may suggest that there was no increase in learning as experience with CPOE increased. Lack of appropriate training before use of CPOE may cause more medication errors and adverse drug events. Physicians, who participated in a study conducted by Yui et al. also mentioned that inexperience with the system was from a lack of training. Senior attending physicians believed that their unfamiliarity with the CPOE system stemmed from a lack of targeted training program (Yui et al., 2012). Also, a study by Devine et al., evaluating the effect of an ambulatory CPOE on medication errors and ADEs, found that after implementing and training physicians on the CPOE, frequency of errors declined from 18.2% to 8.2% (Devine et al., 2010).

4.4 Limitations to This Study

This pilot study was successful in identifying gaps in usability issues and performance measures between novice and expert physicians but also contained several methodological limitations. This study was limited to primary care, a small sample size, and consisted of one CPOE from one healthcare institution which means results may not be generalizable to other specialties and other healthcare institutions. The usability test was also conducted using a limited number of clinical tasks and may not represent other actions taken in different clinical scenarios. This study was conducted in a laboratory setting which does not account for distractions physicians may face during a clinical encounter. Although the SUS survey was able to measure user acceptance differences on a cumulative level, one complex task may affect the SUS score given by novice physicians. Although this study contains some methodological limitation, this is a well-controlled study using rigorous triangular evaluation and instructions were clear to the physicians which allowed participants to complete the required tasks.

5 CONCLUSIONS

These results show that higher experience levels with CPOE is not equivalent to being an expert and proficient in using a CPOE. These results may also assist CPOE vendors in improving the user interface for physicians to use the CPOE effectively, which may increase physicians' performance by reducing errors caused from poor usability of the system. Including users in the development or redesign of CPOE may assist in user performance. For example, testing the language in the menus with actual physician users in a group session may help to identify best terms to use in menu items that users may find more natural. This redesign may improve physicians' accuracy when completing tasks in the CPOE. This pilot provides sufficient preliminary data for a larger, evaluative study of usability issues of CPOE including multiple institutions and CPOE vendors. Future studies should include a larger sample of physicians and broaden the scope to specialty physicians.

6 REFERENCES

1998. *ISO 9241-11: Ergonomic Requirements for Office Work with Visual Display Terminals (VDTs): Part 11: Guidance on Usability*, International Organization for Standardization.

2001. *Crossing the quality chasm: A new health system for the 21st century,* Washington, DC, National Academies Press.

2006. *Committee on Identifying and Preventing Medication Errors. Preventing Medication Errors,* Washington, DC, The National Academies Press 2006.

2010a. National Ambulatory Medical Care Survey: 2010 Summary Tables. CDC/National Center for Health Statistics.

2010b. Selected patient and provider characteristics for ambulatory care visits to physician offices and hospital outpatient and emergency departments: United States, 2009-2010. *FastStats - Diabetes.* Hyattsville, MD: Centers for Disease Control and Prevention, National Center for Health Statistics.

2011a. Healthcare Reform: Impact on Physicians. *Health Capital Topics.* HealthCapital.com: Health Capital Consultants.

2011b. *MU 2011 Annual Report* (Online). Available: http://www.mydigitalpublication.com/publication/?i=106794 (Accessed April 15 2012).

2011c. *U.S. EMR Adoption Model Trends* (Online). Chicago, IL: Health Information Management Systems Society Analytics. Available: http://www.himssanalytics.org/docs/HA_EMRAM_Overview_ENG.pdf (Accessed 02/21 2014).

2013a. *Health, United States, 2012: With Special Feature on Emergency Care,* Hyattsville MD.

2013b. *University Of Missouri Health Care Achieves Highest Level of Electronic Medical Record Adoption* (Online). Columbia, MO. Available: http://www.muhealth.org/body.cfm?id=103&action=detail&ref=311.

Ash, J. S., Stavri, P. Z. & Kuperman, G. J. 2003. A consensus statement on considerations for a successful CPOE implementation. *Journal of the American Medical Informatics Association,* 10**,** 229-34.

Bangor, A., Kortum, P. & Miller, J. 2009. Determining what individual SUS scores mean: adding an adjective rating scale. *Journal of Usability Studies,* 4**,** 114-123.

Barnum, C. 2003. The magic number 5: Is it enough for web testing? *Information Design Journal,* 11**,** 160-170.

Battaglia, M. 2008. *Convenience sampling. In P. Lavrakas (Ed.), Encyclopedia of survey research methods.,* Thousand Oaks, CA, Sage Publications, Inc.

Berger, R. G. & Kichak, J. P. 2004. Computerized physician order entry: helpful or harmful? *Journal of the American Medical Informatics Association,* 11**,** 100-103.

Braun, V. & Clarke, V. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology,* 3**,** 77-101.

Brooke, J. 1996. SUS-A quick and dirty usability scale. *Usability Evaluation in Industry,* 189**,** 194.

Chan, J., Shojania, K. G., Easty, A. C. & Etchells, E. E. 2011. Usability evaluation of order sets in a computerised provider order entry system. *BMJ Qual Saf,* 20**,** 932-40.

Cordes, R. E. 1993. The effects of running fewer subjects on time-on-task measures. *International Journal of Human-Computer Interaction,* 5**,** 393 - 403.

Devine, E. B., Hansen, R. N., Wilson-Norton, J. L., Lawless, N. M., Fisk, A. W., Blough, D. K., Martin, D. P. & Sullivan, S. D. 2010. The impact of computerized provider order entry on medication errors in a multispecialty group practice. *Journal of the American Medical Informatics Association,* 17**,** 78-84.

Ghahramani, N., Lendel, I., Haque, R. & Sawruk, K. 2009. User satisfaction with computerized order entry system and its effect on workplace level of stress. *Journal of Medical Systems,* 33**,** 199-205.

Higgins, J. 2005. The Correlation Coefficient. *The Radical Statistician***,** 1-26.

Horsky, J., Kaufman, D. R. & Patel, V. L. 2004. Computer-based drug ordering: evaluation of interaction with a decision-support system. *Studies in Health Technology and Informatics,* 107**,** 1063-7.

Khajouei, R. & Jaspers, M. W. 2010. The impact of CPOE medication systems' design aspects on usability, workflow and medication orders: a systematic review. *Methods of Information in Medicine,* 49**,** 3-19.

Kim, M., Shapiro, J., GENES, N., Aguilar, M., Mohrer, D., Baumlin, K. & Belden, J. 2012. A pilot study on usability analysis of emergency department information system by nurses. *Applied Clinical Informatics*, 135-153.

Kjeldskov, J., Skov, M. B. & Stage, J. 2010. A longitudinal study of usability in health care: does time heal? *Int J Med Inform,* 79, e135-43.

Koppel, R., Metlay, J. P., Cohen, A., Abaluck, B., Localio, A. R., Kimmel, S. E. & Strom, B. L. 2005. Role of computerized physician order entry systems in facilitating medication errors. *JAMA,* 293, 1197-203.

Medlineplus. 2013. *Basic metabolic panel* (Online). National Library of Science, National Institues of Health. Available: http://www.nlm.nih.gov/medlineplus/ency/article/003462.htm (Accessed 2/25 2014).

Neinstein, A. & Cucina, R. 2011. An analysis of the usability of inpatient insulin ordering in three computerized provider order entry systems. *J Diabetes Sci Technol,* 5, 1427-36.

Peute, L. W. & Jaspers, M. W. 2007. The significance of a usability evaluation of an emerging laboratory order entry system. *International Journal of Medical Informatics,* 76, 157-68.

Schoen, C., Osborn, R., Huynh, P. T., Doty, M., Peugh, J. & Zapert, K. 2006. On the front lines of care: primary care doctors office systems, experiences, and views in seven countries. *Health Affairs,* 25, w555-w571.

Centers for Medicare & Medicaid Services. 2010. Eligible professional meaningful use core measures, measure 14 of 15. Stage.

Walji, M. F., Kalenderian, E., Tran, D., Kookal, K. K., Nguyen, V., Tokede, O., White, J. M., Vaderhobli, R., Ramoni, R., Stark, P. C., Kimmes, N. S., Schoonheim-Klein, M. E. & Patel, V. L. 2013. Detection and characterization of usability problems in structured data entry interfaces in dentistry. *International Journal of Medical Informatics,* 82, 128-138.

Yui, B. H., Jim, W. T., Chen, M., Hsu, J. M., Liu, C. Y. & Lee, T. T. 2012. Evaluation of computerized physician order entry system-a satisfaction survey in Taiwan. *Journal of Medical Systems,* 36, 3817-24.

Zhan, C. L., Hicks, R. W., Blanchette, C. M., Keyes, M. A. & Cousins, D. D. 2006. Potential benefits and problems with computerized prescriber order entry: Analysis of a voluntary medication error-reporting database. *American Journal of Health-System Pharmacy,* 63, 353-358.