Measurement of CPOE end-user satisfaction among ICU physicians and nurses

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Summary

Background: Implementation of Computerized Provider Order Entry (CPOE) can fail or meet high levels of user resistance for a variety of reasons, including lack of attention to users' needs and the significant workflow changes induced and required by CPOE. End-user satisfaction is a critical factor in IT implementation.

Objective: The goal of this study was to identify criteria to select a valid and reliable questionnaire to measure end-user satisfaction with CPOE.

Methods: We developed seven criteria that can be used to select valid and reliable questionnaires. We applied the selection criteria to existing end-user satisfaction questionnaires.

Results: Most of the questionnaires used to measure end-user satisfaction have been tested for reliability and validity and most of the questionnaires have reasonably reliability and some sort of validity. However, only one questionnaire, the Physician Order Entry User Satisfaction and Usage Survey (POESUS) met most of the other criteria we developed to select a questionnaire to evaluate CPOE implementation. We used the POESUS in our study and compared the results with other studies. Results show that users are moderately satisfied with CPOE.

Conclusion: Using the seven criteria we developed, it is possible to select reliable and valid questionnaires. We hope that in the future this will lead to an increasing number of studies using the same questionnaires. That will improve the possibilities for comparing the results of one study to another (benchmarking).

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Introduction

One of the important applications of information technology to health care is computerized provider order entry (CPOE) [1-3]. Results of several surveys showed that CPOE was only available in 15% of the hospitals [4-6]. Recent estimates suggest that CPOE usage is increasing, but most hospitals are still in the planning stage [6, 7]. When using CPOE, physicians and other providers enter orders directly into the computer instead of using a paper-based system. Because of rapid information retrieval and efficient data management, CPOE systems have the potential to enable clinical decision support and improve the quality of patient care and patient safety [5, 8-12]. Despite the potential benefits of CPOE [13], several attempts to implement CPOE systems have failed, met with high levels of user resistance or produced safety problems [2, 3, 5, 14-18]. CPOE implementation efforts have stumbled for a variety of reasons, including lack of sensitivity to users' needs, and dissatisfaction of users with the technology [16, 17, 19-21].

Why is end user satisfaction important?

Since the introduction of personal computers in the early 1980s, researchers have been interested in evaluating end-user satisfaction with computer systems. End-user satisfaction is conceptualized as "the affective attitude towards a specific computer application by someone who interacts with the application directly" [22]. End users are defined as "individuals who interact directly with the computer" [23, 24]. End-user satisfaction is sometimes confused with usability. Usability is defined as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [25]; therefore, usability is a contributor to end-user satisfaction.

Both theory [26] and empirical studies [27] suggest that user satisfaction contributes to technology usage rather than the reverse. If users are not satisfied with a computer application, they will tend to avoid it and look for other tools for performing their tasks. According to Davis [28] two concepts are important for acceptance of technology: perceived usefulness and perceived ease of use. Perceived usefulness is defined as "the degree to which a person believes using a particular system would enhance his or her job performance". Perceived ease of use is defined as "the degree to which a person believes that using a particular system would be free of effort" [28]. Studies by Davis and colleagues [28, 29] resulted in the development of the Technology Acceptance Model (TAM) [30] that specifies perceived usefulness and perceived ease of use as main predictors of technology adoption. Venkatesh and Davis [31] extended the TAM model to explain perceived usefulness and intention to use technology in terms of social influence and cognitive instrumental processes. The extended model, known as TAM2, has been empirically tested and confirmed in several studies [31, 32]. In a further attempt to integrate the main competing user acceptance models, Venkatesh et al. [33] developed the Unified Theory of Acceptance and Use of Technology (UTAUT). UTAUT has been shown to outperform each of the individual models in its ability to predict technology use [33]. For more information about theoretical backgrounds of technology adoption in health care, see Karsh & Holden [34, 35].

Measuring end-user satisfaction

There are several methods available to measure end-user satisfaction, such as examining actual use of computer systems and applications, conducting interviews with end-users, and using end-user questionnaires. Using a questionnaire is a relatively simple method to collect and analyze data about users' perceptions of their satisfaction with the computer system or application. It is very important to use valid and reliable questionnaires when doing research, an observation which may be considered all too obvious. A questionnaire needs to meet certain minimum criteria. To quote Shortell et al. [36]: "Among the most important criteria of useful measures is that they be theory-based, reliable, valid, relevant to unit of analysis, and relatively easy to administer" (Shortell et al., 1991). However, reality teaches us differently. For example, in a study on *patient satisfaction with health care*, Sitzia [37] evaluated the data of 195 studies. Results showed that in 80% of the studies a

new satisfaction assessment instrument was developed. Sixty percent of the studies in which a new instrument was developed, did not report any data on validity or reliability of the instrument. Only 6% of the studies used instruments which were tested and met the minimum requirements with regard to reliability and validity.

Objectives

In this paper we report on the development and application of a set of criteria to select an existing, valid and reliable instrument to measure end-user satisfaction with a CPOE implementation. Then we report data collected with one of the questionnaires in 4 intensive care units of a medical center.

Method

Criteria for selecting a CPOE end-user satisfaction questionnaire

There are two approaches to conducting a questionnaire-based study. The first is to develop a new questionnaire which is customized for the setting in which it will be used, the population to which it will be administered, and the technology being implemented. However, the process of developing a valid and reliable questionnaire requires substantial time, effort and expertise. Another disadvantage of this approach is that it eliminates the possibility of comparing (benchmarking) the newly collected data with results from previous studies. The second approach is to select an existing questionnaire with established validity and reliability, and – if necessary – to adapt that questionnaire to the specific situation. Using the second approach, based on the literature [36, 38-42] and our own vast experience in survey design and administration [43-48] we developed seven criteria for selecting a questionnaire to measure end-user satisfaction with a CPOE implementation:
1. Domain (general vs. specific)
2. Conceptualization
3. Psychometrics
4. Data for comparison
5. Replication/follow-up studies
6. Specificity
7. Paper and pencil version vs. Web-Based Survey (WBS) version

Domain – general vs. specific

Domain refers to whether a questionnaire focuses on satisfaction with the overall computer system versus a specific application such as CPOE implementation. For example, the QUIS is specifically developed to measure satisfaction with the *interface* (screen, help messages, etc.) of a computer system. POESUS is designed to measure satisfaction with *CPOE* implementation. Other questionnaires (e.g., CUSQ, CSUQ, EUCSQ, USE) are designed to measure *overall* end-user satisfaction with a computer system. If a questionnaire is developed to measure satisfaction with a specific system, it may be adapted to measure satisfaction with another system. However, making changes to a questionnaire can affect its validity and reliability in a substantial manner, as well as create problems for benchmarking [43, 49-51].

Conceptualization – theory based versus empirically based

Conceptualization refers to the method used to develop the questionnaire. Questionnaires comprised of items based on scientifically tested models such as TAM are theory-based. The alternative form of questionnaires developed by expert input and consensus is empirically-based. The advantage of theory-based questionnaires is that, using the theory, the items can be generalized to other settings and population samples than the one for which they were originally developed. Most questionnaires contain a mix of theory-based and empirically-based items.

Psychometrics

Psychometrics or the field of study concerned with the theory and technique of educational and psychological measurement [38] emphasizes the concepts of reliability and validity. Numerous methods exist for evaluating reliability and validity [52-55]. Reliability refers to the issue of measurement repeatability: when we measure something at two different occasions, the two measures should result in the same outcomes. Validity refers to the content of measurement: are we measuring what we think we are measuring? We can evaluate reliability by measuring a concept at two different times (test-retest-reliability), by examining the internal consistency of the responses to questions that are supposed to measure the same concept, and by comparing with other methods of measurement of equal or higher level, for example standardized (and validated) questionnaires. A measure that is often used to evaluate internal consistency is the Cronbach's alpha: it is a measure of the homogeneity of a group of items in a survey or questionnaire. Cronbach's alpha varies between 0 (no homogeneity) to 1 (perfect homogeneity). A Cronbach-alpha score of .70 is accepted as an appropriate minimal level [38]. A questionnaire's reliability is strongly related to the number of items and the number of response categories: the larger the number of items and response categories the higher the reliability of the questionnaire [38].

Three forms of validity can be distinguished [38]: predictive validity, content validity and construct validity. *Predictive validity* (also known as criterion validity) refers to the comparison of the measurement under evaluation to another variable that lies outside the domain of the concept being measured. This variable is known as the criterion or 'the golden standard'. The *content validity* of a measurement instrument can be established by examining the content of the questions very carefully. Are the items (in a concept) well chosen? Do they measure what we think they measure? Do they represent the entire domain of the concept? An often-used method for establishing the content validity of a questionnaire is to ask experts about clarity and completeness of a questionnaire [56]. In addition, one can find out if the questions used to measure a particular concept are well understood by the target population (and 'in their own language) by interviewing them. *Construct validity* is important when measuring abstract concepts (e.g., satisfaction, mental workload, stress). The abstract concept (the construct) is operationalized by several questions. When results of statistical analyses show that the questionnaire items show a high degree of internal consistency, one can conclude that the different questions do indeed refer to one (underlying) construct. Most of the questionnaires listed in ▶Table 1 were tested for one or more form of validity (content, construct and/or predictive validity) and reliability. Reliabilities were high, ranging from 0.89 for the UIS to 0.98 for the perceived usefulness scale of the PUPEU (▶Table 2).

Data for comparison

Data for comparison refers to the availability of data to compare the results of one study with the results of another study. Many publications report data on the internal consistency of a questionnaire. Relatively few studies report scale scores and standard deviations, which are necessary for comparing the results of different studies.

Follow-up studies

Follow-up studies refer to whether a questionnaire has only been used only once, in a specific study, in a specific setting with a specific sample, or that the questionnaire has been used in other studies or follow-up studies in order to (re-)establish reliability and validity of the instrument. If a questionnaire has been used in different settings, with different samples, and yields the same results with regard to reliability and validity, the questionnaire can be used across settings and population samples. Most of the questionnaires on end user satisfaction were tested in replication or follow-up studies, except for the EUCSQ-X and the USE (▶Table 2).

Specificity of use

Specificity of use refers to the setting in which a questionnaire is used. To enable meaningful benchmarking, we recommend that questionnaires be used in similar settings (e.g., hospital or

ICU) with the same technology (e.g., CPOE). Although benchmarking the results of a CPOE implementation against the results of the implementation of a different technology could provide some indication of the satisfaction with the CPOE implementation process and the technology, comparing two CPOE implementations is more likely to provide comparable information. Most of the questionnaires that we identified – with the exception of the QUIS and POESUS (►Table 2) – have been used to test information technologies other than CPOE.

Paper-and-pencil vs. Web-based questionnaires

This criterion refers to the medium used to administer the questionnaire. Paper-and-pencil questionnaires are questionnaires that are used in paper form. Web-based questionnaires are questionnaires that use the Internet as a medium. Most questionnaires were developed to be used in a paper-and-pencil version. Only recently, with the development of the Internet, it has become possible to use Web-based questionnaires. There is a wealth of literature on the comparison between paper-and-pencil and Web-based questionnaires [46, 57-60]. However, most of that literature is limited to comparing response rates: response rates for Web-based questionnaires tend to be equivalent or slightly higher than response rates for paper-and-pencil questionnaires [46, 61, 62], although recent evidence suggests that response rates of Web-based questionnaires are dropping. Little research has focused on the question of equivalence: do Web-based versions of questionnaires produce similar results to paper-and-pencil questionnaires? Some limited research shows that this is the case [63-67]. We advise caution in comparing results of questionnaires used with different modes of administration, unless a test of equivalence has been conducted with the questionnaire in question. Four of the 10 end-user satisfaction questionnaires have been used in a Web-based format (►Table 2).

Applying the criteria to end-user questionnaires

Based on a literature search in ACM Digital Library, PsychINFO, PubMed, and Web of Knowledge, using the search terms [end-user satisfaction] OR [user satisfaction] AND [questionnaire] OR [instrument] OR [inventory] AND [computer system] OR [computer application] OR [information system], we identified 10 questionnaires that measure end-user satisfaction with information systems and that provided information on the criteria listed above (►Table 1). ►Table 2 displays information on each of the criteria for each of the 10 end user satisfaction questionnaires.

Selection of the questionnaire

Based on the criteria described above, the preferred questionnaire for measuring CPOE end user satisfaction should be specific, based on theory, have high reliability (Cronbach's alpha >0.80), provide strong evidence for all types of validity (content, predictive, and construct), have comparative data available for benchmarking, should be used in follow-up studies, have been used to study CPOE implementation, and depending on the intended use (paper-and-pencil vs. WBS) should be used in that manner. See ►Table 2 for a summary of the analysis of the 10 end-user satisfaction questionnaires.

Most of the instruments were developed for *general* use, except for the QUIS that focuses on the computer interface, and POESUS that was specifically developed to evaluate CPOE implementation. Two of the questionnaires have been used for CPOE: POESUS and QUIS. Three of the questionnaires are entirely empirically based, two are entirely theory-based, and five are based on a combination of theoretical and empirical considerations. The EUCSQ-X was developed from the EUCSQ, but we were unable to find any report that it has ever been tested. Internal consistency (Cronbach's α) of most of the questionnaires is high (α>0.80). However, Cronbach's α for SUS is not available and Cronbach's α of the USE questionnaire is only described as "high". Some type of validity has been tested for all of the questionnaires, except EUCSQ-X. Only POESUS and QUIS have been used to compare end-user satisfaction with CPOE implementations. Most of the questionnaires (with the exceptions of the EUCSQ, EUCSQ-X, and USE) have been tested in replication and/or follow-up studies. The CSUQ, EUCSQ, QUIS, and SUS have been used as Web-based questionnaires. The QUIS is limited to measuring satisfaction with an user-computer *interface* rather

than overall user satisfaction, and was not specifically developed to measure end-user satisfaction with CPOE.

Based on its overall fitness, we used POESUS in our study of satisfaction of ICU physicians and nurses with a CPOE implementation. POESUS is specific (criterion 1), but is not based on theory (criterion 2), has been tested for reliability (Cronbach's $\alpha = 0.85$) and construct validity (but not for content and predictive validity [criterion 3]), has data available for comparison (criterion 4), has been used in follow-up studies (criterion 5), has been used in a similar setting, and the same technology (criterion 6) and in our study we used a paper-and-pencil version of the questionnaire, using the same medium as earlier studies have used (criterion 7). See ▶Appendix 1 for POESUS.

Analysis

Study of CPOE implementation in ICUs

In our ongoing study of the evaluation of CPOE implementation in four ICUs in a large hospital in the USA (http://cqpi.engr.wisc.edu/cpoe_home), we used the core of POESUS (16 questions) as part of our three-month post implementation questionnaire. We did not change the wording or response categories of POESUS.

Setting

The study was performed at a 400-bed rural, community tertiary care teaching hospital in the Northeast US in four ICUs, the 24 bed adult intensive care unit (AICU), the 18-bed cardiac ICU (CICU), the 38-bed neonatal ICU (NICU) and the 11-bed pediatric ICU (PICU). The EHR under study was the EpicCare Inpatient Clinical System version Spring 2006 (Epic Systems, Madison, WI), implemented in October 2007. The CPOE with CDS system, clinical documentation (nurse and physician), pharmacy system and the electronic medication administration record were implemented organization-wide all at once. The organization was already using the EHR and CPOE in ambulatory care setting.

Sample

One-hundred-and-twenty nurses and 57 physicians[a] in the four ICUs filled out and returned the survey questionnaire (response rate: 47%). Most of the respondents are female (72%). Average age is 38 years. All of the physicians had a graduate degree. Thirty-three percent of the nurses had some college or technical training; 56% graduated from college; 8% have had some graduate school; 3% have a graduate degree.

Most of the respondents (91%) are Caucasian. Average tenure at the hospital is nearly twelve years. Average tenure in the current ICU is 7 years. Nurses work on average 41.5 hours a week and mostly in 12-hour shifts (74%). Physicians work on average 48 hours per week. Twenty-three percent of the nurses work in the Adult ICU (AICU); 29% in the Cardiac ICU (CICU); 17% in the Pediatric ICU (PICU); and 26% in the Neonatal ICU (NICU). Thirty-seven percent of the physicians work in the AICU, 30% in the CICU, 15% in the PICU and 18% in the NICU.

Data collection procedures

Questionnaires were personally distributed to ICU physicians and nurses by the research team. They were asked to fill out the survey and put the completed survey in a mailbox, which was left in the ICU's conference room. Response rates were 51% for nurses and 40% for physicians (including NPs and PAs).

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[a] Fifteen attendings, 10 fellows, 13 residents, 9 interns, 3 physician assistants (PA) and 3 nurse practitioners (NP). The PAs and NPs are included among the physicians because they enter orders in CPOE.

Results

The results of the evaluation of CPOE end user satisfaction among ICU physicians and nurses are summarized in ▶Table 3.

We also compared our results to two previous studies that used the POESUS questionnaire. Lee et al. [3] created the POESUS and used it in a study of 112 physicians and 93 nurses at the Brigham and Women's Hospital (BWH) in Boston, a 720-bed affiliate of Harvard Medical School. A CPOE system was developed at BWH in 1992 and first implemented in the medical service (200 beds) in May 1993. Surgical and orthopedic services started using CPOE at the end of 1993. At the time of the study, only medical, surgical, and orthopedic services were using CPOE.

The study by Wilson and colleagues [68] examines CPOE end user satisfaction among 243 providers authorized to place orders into the DOD Composite Health Care System (CHCS) (including 2 clinical pharmacists) and all pharmacy staff members (staff pharmacists and technicians) who were assigned to two DOD treatment facilities consisting of a 48-bed community hospital and an outpatient clinic. In order to improve the comparison of our data to the data of this study, we focus on the 111 physicians who participated in the study.

Results in ▶Table 3 show that ICU physicians and nurses in our study are moderately satisfied with the CPOE technology (mean of 4.06 on item 16 about overall CPOE satisfaction; scale from 1-Never to 4-It varies to 7-Always, midpoint: 4). The mean scores on overall satisfaction are 5.07 in the Lee et al. study [3] and 3.78 in the study by Wilson and colleagues [68]. Results of all three studies show that overall user satisfaction with CPOE technology is not high. The ICU physicians and nurses in our study rated the following CPOE characteristics as rather positive: getting help when having problems with CPOE (mean = 5.12), and reliability of CPOE technology (mean = 4.47). On the other hand, slowness of CPOE as compared to paper ordering (mean = 4.56) was a somewhat negative characteristic of CPOE as perceived by the ICU physicians and nurses. Results of our study show significantly higher scores on the different aspects of user satisfaction than the scores in study by Wilson et al [68].

Results of our study and the Lee et al. [3] study show that physicians tended to be more satisfied with the CPOE system than nurses. In our study, we found statistically significant differences between physicians and nurses on 6 out of 16 POESUS items: physicians reported greater satisfaction than nurses on issues such as reliability, reduction of patient care errors and improvement of quality of patient care.

Conclusion

CPOE systems are being increasingly implemented in hospitals and other healthcare settings. Hospitals that implement this technology need to evaluate the impact of the CPOE technology on end users in order to identify problems with implementations and to plan continuing optimization initiatives. Several studies have shown that end-user satisfaction is a critical factor in IT implementation. We developed 7 criteria to select a questionnaire to measure end-user satisfaction with CPOE and applied the criteria to existing end-user questionnaires. Using the criteria, we were able to select a questionnaire – the POESUS – and we recommend the use of the POESUS questionnaire because of its strengths, including its appropriateness for comparing the results of CPOE implementations across hospitals. In our study of the evaluation of CPOE implementation in four ICUs in a large hospital, we used the POESUS and reported on the results. This comparative information has the potential to be used to improve the design, implementation and use of CPOE technology.

Implication of results for practitioners and/or consumers

CPOE implementation efforts have stumbled for a variety of reasons, including lack of sensitivity to users' needs and dissatisfaction of users with the technology. In this paper we described and applied criteria to select a valid and reliable instrument to measure end-user satisfaction, in this case with CPOE implementation. Health care organizations that will implement CPOE in the future can use the same, short questionnaire to benchmark their results against the results described in this study.

Conflict of Interest

Acknowledgements

Human Subject Research Approval

This study was approved by the institutional review boards of the University of Wisconsin-Madison and Geisinger Health System.

Table 1 Description of 10 questionnaires for measuring end-user satisfaction

#	Name	Authors	Concepts measured	# Items	Response categories
1	Computer User Satisfaction Questionnaire (CUS-Q)	Bailey & Pearson 1983 [70]	39 factors affecting satisfaction	156	Four semantic differential scales (1-7) per item
2	Computer System Usability Questionnaire (CSU-Q)	Lewis 1995 [71]	System usefulness Information quality Interface quality	19	Likert scale (1-7) Strongly agree-Strongly disagree
3	End-user Computing Satisfaction Questionnaire (EUCS-Q)	Doll & Torkzadeh 1988 [22]	Content Accuracy Format Ease of use Timeliness	12	Likert scale (1-5)
4	Extended End-user Computing Satisfaction Questionnaire (EUCS-Q-Xb)	Chin & Lee 2000 [72]	Content Accuracy Format Ease of use Timeliness Satisfaction with computing speed	29	Likert scale (1-5)
			Prior expectations Prior needs	+ 14 + 14	
5	Physician Order Entry User Satisfaction and Usage Survey (POESUS)	Lee et al. 1996 [3]	Reliability Speed Ease of use Adequacy of training Impact on Productivity and patient care	16	Likert scales (1-7) Never-Always
			Features of CPOE	+9	Not useful at all-extremely useful
6	Perceived Usefulness and Perceived Ease of Use questionnaire (PUPEU)	Davis 1989 [28]	Usefulness Ease of Use	12	Likert scale (1-7) Strongly agree-Strongly disagree
7	Questionnaire for User Interface Satisfaction (QUIS v5)	Chin et al. 1998 [73]	Overall reactions to the software Screen Terminology and system information Learning System capabilities	21	Semantic differential scales (0-9)
8	System Usability Scale (SUS)	Brooke, 1996 [74]	Usability	10	Likert scale (1-5) Strongly agree-Strongly disagree
9	User Information Satisfaction (UISc)	Yves et al (1983) [75]	Staff and services Information Product User knowledge and involvement	26	Two semantic differential scales (1-7) per item

b EUCS-Q-X is the extended version of EUCS-Q. As far as we know, it has never been tested in a validation study.
c UIS is the short version of CUSQ

#	Name	Authors	Concepts measured	# Items	Response categories
10	Usability, Satisfaction & Ease of use questionnaire (USE)	Lund 2001 [76]	Usefulness Ease of use Ease of learning Satisfaction	30	Likert scale (1-7) Strongly agree-Strongly disagree

Notes: + means that apart from the core questionnaire, the questionnaire contains an additional number of questions on specific topics. A Likert scale is the sum of responses on several Likert items. A Likert item is a statement which the respondent is asked to evaluate according to any kind of subjective or objective criteria; generally the level of agreement or disagreement is measured. The format of a typical five-level Likert scale is: (1) Strongly disagree, (2) Disagree, (3) Neither agree nor disagree, (4) Agree, and (5) Strongly agree. The Semantic Differential (SD) measures people's reactions to stimulus words and concepts in terms of ratings on bipolar scales defined with contrasting adjectives at each end. An example of a SD scale is: Good (1), (2), (3), (4), (5) Bad.

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Table 2 Characteristics of end-user satisfaction questionnaires

	Name	Domain	Conceptualization	Cronbach's α	Validity	Data for comparison available	R/F Study	CPOE	WBS
1	CUSQ	G	L/T/E	0.93	Content Predictive Construct	Y	Y [75, 77]	N	N
2	CSUQ	G	L/E	0.95	Content Construct	N	Y [78, 79]	N	Y[78, 79]
3	EUCSQ	G	T	0.92	Content Predictive Construct	N	Y [80-84]	N	Y[82]
4	EUCSQ-X	G	T	-	-	-	-	-	-
5	POESUS	S	E	0.85	Construct	Y	Y [68]	Y[3, 68]	N
6	PUPEU	G	L/T	0.98 0.94	Content Predictive Construct	N	Y [85-88]	N	N
7	QUIS	G/S	E	0.94	Predictive Construct	Y	Y [89, 90]	Y[8]	Y[90, 91]
8	SUS	G	E	N/A	Predictive Construct	N	Y [92, 93]	N	Y
9	UIS	G	L/E	0.89	Content Predictive Construct	Y	Y [94-96]	N	N
10	USE	G	L/E	"high"	Construct	N	N	N	N

G = General, S = Specific; L/T/E = Literature Review/Theoretical/Empirical; R/F Study = Replication/Follow-up study available; CPOE = Used in CPOE implementation study; WBS = Web Based Survey; Y = Yes; N = No

Table 3 Reference scores for the items in POESUS in three studies (A, B and C): Means (on a scale from 1-7), standard deviations (SD), sample size [N] comparisons (Comp.) and statistically significant differences (Sign.) between the three studies.

		A: Lee et al., 1996			B: Wilson et al., 2000	C: This study			Comp.	Sign.
		A: All [N = 205]	A1: Physicians [N = 112]	A2: Nurses [N = 93]	B Physicians [N = 112]	C: All [N = 177]	C1: Physicians [N = 54]	C2: Nurses [N = 121]		
		Mean (SD) [N]	Mean (SD) [N]	Mean (SD) [N]	Mean (SD) [N]	Mean (SD) [N]	Mean (SD) [N]	Mean (SD) [N]		
1	The order entry system is reliable – it does its job consistently.				3.93 (0.97) [N = 106]	4.47 (1.10) [N = 162]	5.94 (1.00) [N = 52]	4.25 (1.05) [N = 108]	B/C C1/C2	*** ***
2	Order entry improves my productivity.				3.68 (1.08) [N = 106]	3.83 (1.56) [N = 163]	4.25 (1.64) [N = 52]	3.62 (1.48) [N = 109]	B/C C1/C2	NS *
3	Order entry has a negative impact on patient care.				2.09 (0.89) [N = 107]	4.09 (1.49) [N = 163]	3.88 (1.53) [N = 52]	4.18 (1.48) [N = 109]	B/C C1/C2	*** NS
4	Order entry reduces patient care errors.				3.50 (0.97) [N = 107]	4.06 (1.16) [N = 163]	4.53 (1.16) [N = 51]	3.83 (1.10) [N = 110]	B/C C1/C2	*** ***
5	The order entry system is easy to use.				3.50 (1.07) [N = 106]	3.94 (1.42) [N = 158]	4.22 (1.54) [N = 51]	3.80 (1.33) [N = 105]	B/C C1/C2	* NS
6	Compared to paper ordering, order entry slows me down.				2.70 (1.26) [N = 103]	4.56 (1.71) [N = 164]	4.62 (1.81) [N = 52]	4.55 (1.67) [N = 110]	B/C C1/C2	*** NS
7	Order entry gives me the information I need to write better orders.				3.36 (1.09) [N = 96]	4.06 (1.21) [N = 138]	4.40 (1.24) [N = 52]	3.82 (1.14) [N = 84]	B/C C1/C2	*** **
8	I feel I had adequate training on order entry.		4.65 (-) [N~112]	4.77 (-) [N~93]	3.49 (1.00) [N = 99]	4.04 (1.45) [N = 149]	4.85 (1.20) [N = 52]	3.58 (1.38) [N = 95]	B/C C1/C2	** ***
9	Order entry improves the quality of patient care.				3.57 (0.98) [N = 106]	3.99 (1.38) [N = 156]	4.67 (1.14) [N = 51]	3.62 (1.35) [N = 103]	B/C C1/C2	* ***
10	System response time on order entry is slow.				2.81 (1.19) [N = 105]	3.88 (1.38) [N = 158]	4.08 (1.48) [N = 52]	3.80 (1.31) [N = 105]	B/C C1/C2	*** NS

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		A: Lee et al., 1996			B: Wilson et al., 2000	C: This study			Comp.	Sign.
		A: All [N = 205]	A1: Physicians [N = 112]	A2: Nurses [N = 93]	B Physicians [N = 112]	C: All [N = 177]	C1: Physicians [N = 54]	C2: Nurses [N = 121]		
		Mean (SD) [N]	Mean (SD) [N]	Mean (SD) [N]	Mean (SD) [N]	Mean (SD) [N]	Mean (SD) [N]	Mean (SD) [N]		
11	When I have a problem with order entry, I just ask someone for help.				3.51 (0.92) [N = 103]	5.12 (1.28) [N = 152]	4.90 (1.13) [N = 52]	5.24 (1.36) [N = 98]	B/C C1/C2	*** NS
12	I feel that I can benefit from refresher classes on order entry.				3.22 (1.16) [N = 101]	3.82 (1.77) [N = 152]	3.67 (1.72) [N = 52]	3.91 (1.81) [N = 98]	B/C C1/C2	** NS
13	When I need help on order entry, I can find it.				3.21 (1.06) [N = 98]	4.36 (1.36) [N = 151]	4.62 (1.32) [N = 52]	4.22 (1.37) [N = 97]	B/C C1/C2	*** NS
14	Overall, order entry improves the safety of care I provide				-	4.18 (1.33) [N = 158]	4.71 (1.24) [N = 51]	3.90 (1.30) [N = 105]	B/C C1/C2	- **
15	Overall, order entry saves me time.				-	3.70 (1.66) [N = 159]	4.21 (1.71) [N = 52]	3.46 (1.56) [N = 105]	B/C C1/C2	- **
16	Overall, I am satisfied with the order entry system.	5.07 (1.30) [N = 205]	5.26 (1.45) [N = 112]	4.84 (1.30) [N = 93]	3.78 (0.87) [N = 106]	4.06 (1.42) [N = 159]	4.56 (1.26) [N = 52]	3.80 (1.44) [N = 105]	A1/A2 A/B A/C B/C C1/C2	* *** *** NS **

Note: Comp = Comparison, Sign = Significance. *, **, *** = statistically different at p<0.05, p<0.01, and p<0.001 respectively. Items 3, 6, 10 and 12 are in reversed order meaning that a low(er) score is favorable.

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Appendix 1

Physician Order Entry User Satisfaction and Usage Survey – POESUS [3]

The original Physician Order Entry User Satisfaction and Usage Survey (POESUS) [3] contains several parts. The first part (questions 1-16) contains the questions about end-user satisfaction used in this paper.

Based on your experience, please indicate whether the following statements about order entry are true on a scale from Never (1) –Always (7)

	Never			It varies			Always
1. The order entry system is reliable – it does its job consistently.	☐1	☐2	☐3	☐4	☐5	☐6	☐7
2. Order entry improves my productivity.	☐1	☐2	☐3	☐4	☐5	☐6	☐7
3. Order entry has a negative impact on patient care.	☐1	☐2	☐3	☐4	☐5	☐6	☐7
4. Order entry reduces patient care errors.	☐1	☐2	☐3	☐4	☐5	☐6	☐7
5. The order entry system is easy to use.	☐1	☐2	☐3	☐4	☐5	☐6	☐7
6. Compared to paper ordering, order entry slows me down.	☐1	☐2	☐3	☐4	☐5	☐6	☐7
7. Order entry gives me the information I need to write better orders.	☐1	☐2	☐3	☐4	☐5	☐6	☐7
8. I feel I had adequate training on order entry.	☐1	☐2	☐3	☐4	☐5	☐6	☐7
9. Order entry improves the quality of patient care.	☐1	☐2	☐3	☐4	☐5	☐6	☐7
10. System response time on order entry is slow.	☐1	☐2	☐3	☐4	☐5	☐6	☐7
11. When I have a problem with order entry, I just ask someone for help.	☐1	☐2	☐3	☐4	☐5	☐6	☐7
12. I feel that I can benefit from refresher classes on order entry.	☐1	☐2	☐3	☐4	☐5	☐6	☐7
13. When I need help on order entry, I can find it.	☐1	☐2	☐3	☐4	☐5	☐6	☐7
14. Overall, order entry improves the safety of care I provide.	☐1	☐2	☐3	☐4	☐5	☐6	☐7
15. Overall, order entry saves me time.	☐1	☐2	☐3	☐4	☐5	☐6	☐7
16. Overall, I am satisfied with the order entry system.	☐1	☐2	☐3	☐4	☐5	☐6	☐7