Proposed model to determine satisfaction with computerised provider order entry systems in a long-stay hospital

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ABSTRACT

Objectives Computerised provider order entry (CPOE) systems reduce medication errors, but are not without dangers. Knowing satisfaction with the CPOE helps to improve its implementation. Our objective was to determine the satisfaction of healthcare professionals with the CPOE in a long-stay hospital and to propose a single model.

Methods A cross-sectional study in a long-stay hospital. Two questionnaires were distributed to determine satisfaction with CPOE, one for medical personnel (MP) and another for nursing personnel (NP). Data collected were: sex, age and work aspects. A strategy for item refinement and creation of a single scale was designed.

Results The overall participation rate was 63.6%, with 68 responses from the target population of 107. Overall, 72.2% (13 of 18) of MP and 40% (20 of 50) of NP were satisfied with CPOE. Regarding the specific questions on satisfaction in the questionnaires, 88.9% (n=16) of MP were very satisfied but only 56.0% (n=28) of NP. The median of each question was 4, with the exception of those for NP referring to a faster process and improved coordination, which were 3 and 3.5, respectively. The items weighing more in the second component were eliminated and the questions merged. After refining the items, a final six-item model was obtained with a single component of high reliability (Cronbach's $\alpha=0.896$), which accounts for 67% of total variance.

Conclusion The degree of satisfaction with CPOE in a long-stay hospital was high, though lower in NP than MP. Obtaining a single questionnaire can facilitate this process.

INTRODUCTION

Patient safety should be one of the priority objectives of the healthcare system. According to the literature,¹ medical errors were the third leading cause of death in the USA in 2015. Therefore, the implementation of active strategies to promote a patient safety culture in the whole organisation is imperative.²

Completely safe drug use is a goal that has yet to be successfully achieved in hospitals. In fact, the ENEAS³ study, conducted in 24 Spanish hospitals, found a 9.3% incidence of patients with adverse effects, most of which were directly related to hospital care. In 22.2% of cases, the adverse event caused readmission of the patient and more than a third (37.4%) were related to medication. The

fact that nearly half of medication-related incidents (42.8%) were avoidable or preventable needs to be emphasised.

Over the last years, many measures have been introduced to reduce or limit medication errors in healthcare institutions, regardless of their activities or purposes.²⁻⁵ Among these measures are computerised provider order entry (CPOE) systems. CPOE systems contribute to hospitalised patients' safety by integrating a wide range of clinical information and including a powerful safety alert system.⁵⁻⁸ Because of their advantages, CPOE systems were introduced in Spanish hospitals more than a decade ago, initially in university reference hospitals.⁹⁻¹¹ Since then, their use has increased exponentially throughout the entire Spanish health system.

One of the most widespread CPOE systems is Prisma Athos, used mostly in the southern and eastern areas of Spain.¹⁰ Like other CPOE systems, it has various safety levels with basic information to facilitate prescription (maximum dose, predefined regimens, days of treatment, interactions, contraindications and duplications), pharmacy validation and later distribution. It also includes the administration of medications with optical readers in order to check treatment suitability at the patient's bedside.⁶⁻¹⁰⁻¹²

Undoubtedly, a CPOE system provides many benefits from the perspective of patient safety. It has been proven to reduce medication errors, with a particular reduction in prescription errors.⁶⁻⁸⁻¹² Nevertheless, CPOE systems have been criticised due to their low therapeutic flexibility, slowing down the therapeutic process and increasing bureaucracy and technology dependence, among other issues.⁷⁻¹⁰ These criticisms have led to efforts to improve the system and enhance its acceptance among healthcare professionals.¹⁰⁻¹³⁻¹⁴

Satisfaction with CPOE systems is not as good as it might be expected, obtaining divergent results in different hospitals, mainly in university hospitals or in tertiary care centres that treat acute patients.⁶⁻⁹⁻¹¹⁻¹² It should be mentioned that medication errors can occur using CPOE systems due to a lack of configuration or their use in special patients such as paediatric patients or in special services for which they were not designed.⁶⁻⁹⁻¹⁵

There is no record of this satisfaction in a medium long-stay hospital, either nationally or internationally.

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Table 1 Main study variables

Variables	Medical personnel n=18	Nursing personnel n=50	p Value
Age in years, mean (SD)*	52.2 (7.94)	45.4 (10.6)	0.014
Women/men, n (%)	5/13 (27.8/72.2)	41/9 (82.0/18.0)	0.498†
Years of career, n (%)			0.053†
≤10 years	0 (0)	11 (22.0)	
>10 years	18 (100)	39 (78.0)	
Time in the hospital, n (%)			0.055
≤10 years	5 (27.8)	28 (56.0)	
>10 years	13 (71.4)	22 (44.0)	
Time in the current position, n (%)			0.004
≤10 years	6 (33.3)	36 (72.0)	
>10 years	12 (66.7)	14 (28.0)	
Works at night, n (%)	13 (72.2)	38 (76.0)	0.758†
Works on holidays, n (%)	13 (72.2)	39 (78.0)	0.747†

*SD.

†Fisher's exact test.

Different questionnaires have been used to assess healthcare professionals' satisfaction with CPOE, some of which were specifically designed for this purpose.^{16–19} Almost all have shown high reliability and adequate apparent, content, criterion, divergent/convergent and construct validity.²⁰ Healthcare professionals' interaction can be considered as satisfactory in general, as long as technology does not become a problem and it has technical support, especially during its introduction.^{8 10 13 17–19} In our setting, a double questionnaire designed by the authors has been recently used to measure satisfaction with CPOE.¹⁶ It had two variants, one for medical personnel (MP) and another for nursing personnel (NP), due to their differing perceptions, obtaining results quite similar to previous studies.¹⁸

The aim of this study was to determine healthcare personnel's satisfaction with CPOE systems in a long-stay hospital. In our hypothesis, it is assumed that CPOE satisfaction has a single domain, therefore a further objective was to propose a single model that simplifies and accelerates data collection, measurement and analysis.

MATERIALS AND METHODS

A cross-sectional study was carried out in a long-stay hospital during the first week of February 2017. Two specific questionnaires were distributed,¹⁶ one for MP and another for NP, in order to determine their satisfaction with CPOE (Prisma APD). CPOE (Prisma APD) was introduced in all hospitalisation units (187 beds) in October 2015.

Possible confounder variables were collected: sex, age, years worked, years in the hospital, years in the current position and working at night or holiday shifts. The inclusion criteria were: All permanent or temporary NP (95) or MP (28) who work full-time and use the CPOE. The healthcare professionals not using the CPOE for working in services where medication is not prescribed or administered were excluded: target population was 22 MP and 85 NP.

Questionnaires were distributed via the hospital's internal mail service. The time required to complete the questionnaire was about 10 min and was collected by nursing supervisors, assisted by pharmacy department personnel. Anonymity was guaranteed, as questionnaire distribution, completion, collection, recording and analysis of results were performed according to Spanish Organic Law 15/1999 on Personal Data Protection.

NP and MP questionnaires contain 10 (NP1 to NP10) and 9 (MP1 to MP9) item questions, respectively.¹⁶ All use a Likert scale with five possible answers ranging from 1 (very dissatisfied) to 5 (very satisfied). The answers to each question with a value of 1 (very dissatisfied/strongly disagree) or 2 (dissatisfied/disagree) were considered as negative or dissatisfied, and the ones with a value of 4 (satisfied/agree) or 5 (very satisfied/strongly agree) as positive or satisfied. The answers with a value of 3 (neither agree or disagree/average/no change) were not taken into account in the analysis of each item scale but were considered for the overall score. Participants with an overall scale score of 40 or above (range: 10–50) for NP or 36 (range: 9–45) for MP were considered as satisfied with the CPOE.

Item selection and refinement

From the total score obtained for each item, a strategy was designed for selecting items to create a new single scale.²¹ To do so, the reliability and validity of the initial, intermediate and final scales were assessed.^{18 20} First, the two original scales were assessed in order to obtain scales with a single component by eliminating the items with higher weight in the second component. These same items were eliminated in the other scale as well since they were identical and had the same relationship. The effect of this refinement was assessed.²¹

Second, in order to build a single scale, the common questions in both questionnaires were joined together, with the following merged items (iM): iM4=MP3 NP5; iM5=MP4 NP6; iM6=MP5 NP7; iM7=MP7 NP9; iM8=MP6 NP8; iM9=MP8 NP10. Two more similar questions were merged as they only differed in one word: iM1=PF1-PE1; iM2=PF2-PE2. Two additional items referring to administration and prescription were unified: iM3=PF9-PE3. One item of the scale remained intact iM=PE4.

Once the new items were defined, a refinement process was performed, assessing their internal consistency using a principal component analysis without rotation in order to obtain a final questionnaire.^{20 21}

Statistical analysis

The results of categorical variables were expressed as absolute frequencies and percentages. These variables were compared using a χ^2 test or a Fisher's exact test. For variables with more than two categories, the Mantel-Haenszel tendency test was used for analysis. The results of quantitative variables (such as the total scores obtained for the scales) were expressed as mean and SD and were compared using the Student's t-test if the samples were independent or the Shapiro-Wilk test if they did not fit normality criteria. For all tests, the significance level was set at 5%. The software used for the statistical analysis was IBM SPSS Statistics V.19 for Windows (IBM).

An overall explanatory model was obtained by logistic regression. It was adjusted for potential confounding variables according to the Maldonado and Greenland criteria²² and the Hosmer-Lemeshow test was used to assess overall goodness of fit of the model.

Cronbach's α ^{18 20} was used to assess the reliability of the original and merged scales and those obtained subsequently. In addition, it was used as a criterion to select and eliminate items.²¹ In order to assess the validity of each scale, a principal component analysis without rotation was performed. In addition, the Bartlett sphericity test and the Kaiser-Meyer-Olkin (KMO) test were performed to determine its appropriateness and the proportion of variance explained.

Table 2 Nursing personnel results. Original scale*

Questions	Negative n (%)	Positive n (%)	Mean (95% CI)
1. CPOE improves the available drug information (administration route, dosage, and so on) at the time of administration.	4/50(8)	42/50 (84)	4.08 (3.84 to 4.32)
2. Using CPOE, patient information (name, age, medical history record, diagnosis, and so on) is clearer.	5/50(10)	39/50 (78)	3.96 (3.67 to 4.25)
3. The record of administration is more readable.	4/50(8)	40/50 (80)	4.00 (3.74 to 4.26)
4. The recording of the medication on CPOE increases the safety of the process.	4/50(8)	35/50 (70)	3.86 (3.59 to 4.13)
5. CPOE makes the treatment process faster.	12/50(24)	24/50 (48)	3.42 (3.11 to 3.73)
6. CPOE increases patient safety and reduces medication errors.	10/50(20)	33/50 (66)	3.66 (3.34 to 3.98)
7. CPOE improves doctor-pharmacist-nurse coordination in the process required for drug prescription, validation and administration.	10/50(20)	25/50 (50)	3.44 (3.13 to 3.75)
8. Assess the pharmacy department's collaboration in the resolution of problems and incidents related to CPOE.	12/50(24)	29/50 (58)	3.38 (3.06 to 3.70)
9. Overall, CPOE is better than the manual process. If you disagree, please explain briefly your reasons.	5/50(10)	37/50 (74)	3.90 (3.61 to 4.19)
10. I am very satisfied with the Prisma CPOE system.	9/50(18)	28/50 (56)	3.60 (3.29 to 3.91)

*95% CI.

CPOE, computerised provider order entry system.

RESULTS

The overall participation rate was 63.6% (n=68; target population n=107), and was higher in MP (n=18; 81.8%) than in NP (n=50; 58.8%). The principal variables considered for each group are shown in [table 1](#) and only differ significantly in age and the years in the current position.

The number of positive and negative answers to each item and the mean value are shown in [table 2](#) for MP and in [table 3](#) for NP. Overall, 72.2% of MP (n=13) but only 40% of NP (n=20) seemed satisfied with CPOE. Nevertheless, taking into account the answers to the general question about satisfaction with the CPOE (question numbers 8 and 10 of the MP and NP questionnaires, respectively), 16 MP (88.9%) and 28 NP (56.0%) were very satisfied.

The mean overall score did not differ significantly between both groups ($t=0.022$; $p=0.982$), which was 37.33 (range: 31–45) for MP and 37.3 (range: 11–50) for NP. No answer distribution followed the normal law and a ceiling effect was observed for most items in both scales. All the questions had a median of 4 with the exception of the NP questions related to a faster process (median=3.0) and improved coordination (median=3.5). Including all the potential confounding variables

in the logistic regression, positive satisfaction did not significantly fit the scale for NP ($p=0.540$) or MP ($p=0.806$).

Reliability was higher for the NP (Cronbach's $\alpha=0.935$) than the MP scale (Cronbach's $\alpha=0.770$), although both were quite high. The other parameters considered for the validity of the two original scales are shown in [table 4](#). Both scales have two factors with an eigenvalue higher than 1, which explain 76% of the NP variance. However, the MP scale had a lower KMO index and proportion of explained variance (60.1%).

MP and NP scale commonalities are shown in [table 5](#). In the MP scale, item number 8 related to overall satisfaction did not have the greatest weight in component 1 (commonality=0.700), but item MP5 instead. In contrast, in the NP scale, the question about overall satisfaction did have the greatest weight in the first component (commonality=0.944).

Eliminating from the scales the items that had the greatest weight in component 2, that is, item 3 for MP (commonality=0.646) and item 8 for NP (commonality=0.830) ([table 5](#)), modified scales were obtained with a single component and increased reliability (Cronbach's α) versus the originals by 0.012 in the NP scale and 0.018 in the MP scale, thus meeting the criterion for eliminating these items from their respective scale.

Table 3 Medical personnel results. Original scale*

Questions	Negative n (%)	Positive n (%)	Mean (95% CI)
1. CPOE improves the available drug information (different drugs, dosage, administration route, and so on) at the time of prescription.	0/18 (0)	18/18 (100)	4.39 (4.14 to 4.64)
2. CPOE allows easier access to patient information (name, age, medical history record, diagnosis, and so on).	1/18 (5.6)	15/18 (83.3)	4.11 (3.60 to 4.62)
3. CPOE makes the treatment process faster.	5/18 (27.8)	12/18 (66.7)	3.61 (2.97 to 4.25)
4. CPOE increases patient safety and reduces medication errors.	0/18 (0)	18/18 (100)	4.39 (4.14 to 4.64)
5. CPOE improves doctor-pharmacist-nurse coordination in the process required for drug prescription, validation and administration.	1/18 (5.6)	15/18 (83.3)	4.17 (3.74 to 4.59)
6. Assess the pharmacy department's collaboration in the resolution of problems and incidents related to CPOE.	0/18 (0)	17/18 (94.4)	4.22 (3.95 to 4.49)
7. Overall, CPOE is better than the manual process. If you disagree, please explain briefly your reasons.	0/18 (0)	18/18 (100)	4.44 (4.19 to 4.70)
8. I am very satisfied with the Prisma CPOE system.	0/18 (0)	16/18 (88.9)	4.00 (3.76 to 4.24)
9. Does CPOE facilitate drug prescription to patients?	0/18 (0)	16/18 (88.9)	4.00 (3.76 to 4.24)

*95% CI.

CPOE, computerised provider order entry system.

Table 4 Reliability and validity of the different scales obtained in the item cleansing process

Model	Modification made	Item number	Components*	Bartlett sphericity test	KMO	Proportion of variance explained (%)	Cronbach's α (95% CI)
Nursing	Original	10	2	421.351 ($p<0.001$)	0.898	76.1	0.935 (0.905 to 0.959)
Medical	Original	9	2	61.633 ($p=0.005$)	0.630	60.6	0.770 (0.568 to 0.900)
Nursing reduced	Eliminate item 8	9	1	398.667 ($p\leq 0.001$)	0.921	71.1	0.947 (0.922 to 0.967)
Medical reduced	Eliminate item 3	8	1	33.148 ($p=0.004$)	0.778	54.2	0.788 (0.599 to 0.908)
Nursing (by analogy)	Eliminate item 5	8	1	353.877 ($p\leq 0.001$)	0.923	72.8	0.945 (0.918 to 0.965)
Medical (by analogy)	Eliminate item 6	7	1	26.275 ($p=0.003$)	0.765	57.9	0.758 (0.538 to 0.896)
Merged	Merged item	8	1	353.877 ($p<0.001$)	0.923	72.8	0.945 (0.918 to 0.965)
Seven items	Eliminate iM4	7	1	360.819 ($p<0.001$)	0.909	69.6	0.923 (0.892 to 0.948)
Final	Eliminate iM8	6	1	243.745 ($p<0.001$)	0.877	67.0	0.896 (0.853 to 0.930)

*Extraction method: principal component analysis without rotation.

iM, merged items; KMO, Kaiser-Meyer-Olkin index.

By analogy, the previously refined question was eliminated from each scale, that is, eliminating item number 5 from the NP scale and item number 3 from the MP scale. Results quite similar to their preceding scales were obtained, but showing an improvement in the proportion of variance explained, as can be seen in table 4.

Both single-component scales were then merged into a single scale allowing the satisfaction of all healthcare professionals involved to be measured. It was not necessary to merge the previously refined items, such as the one previously defined in the Methods section as item 7. This merged scale with eight items, shown in table 4, explained the variance and had a reliability similar to the one obtained in the previous NP model. Given that the Bartlett sphericity test was significant and the KMO index was high enough, a factor analysis was performed.

To refine the merged scale, item iM4=MP4 showed a high correlation to NP6 ($r=0.789$; $p<0.001$), therefore it could be eliminated in future questionnaires. The properties of the resulting seven-item model are shown in table 4, which does not show large differences compared with the merged model. In addition, item iM8 on overall CPOE satisfaction can be also eliminated because of its redundancy with the single domain construct that we are trying to measure.

The final six-item model with a single component has high reliability, greater than 0.896, and explains 67% of the total variance. This final model was constructed with 11.3 responders per item. This scale has a range of 6–30 points, with a cut-off point for assessing individual satisfaction of 24 points (see online

supplementary appendix 1). The answer distribution for each item of the final scale is shown in figure 1, all items having a median of 4. The mean of the obtained scores was 23.7 (SD: 4.67) points. If the new scale were used, 58.8% of the participants ($n=40$) would be satisfied with CPOE, differing significantly from MP (15 satisfied; 83.3%) to NP (25 satisfied; 50%) (Fisher's exact test: $p=0.024$). When an explanatory model was performed using multivariate logistic regression ($p=0.953$), the only significant variable was the type of healthcare professional ($p=0.028$), with an OR=5.63 (95% CI 1.20 to 23.96) taking as reference the NP.

DISCUSSION

Our results show quite good satisfaction with CPOE, which was higher for doctors than for nurses as in some previous studies,^{5 15} but in contrast with others, where NP satisfaction was higher.^{16 17} If the final proposed scale had been used, the results obtained would have been similar in terms of overall satisfaction with CPOE. These differences in overall satisfaction with CPOE among healthcare professionals may be due to diverse causes,^{5 15–17 23 24} but doubtlessly each one uses the system differently during their daily tasks and their needs are probably different as well. Indeed, not having a virtual system in our hospital to record medication administration parallel to the CPOE system may have caused lower satisfaction with the CPOE

Table 5 Commonalities obtained in the factor analysis of the original scales*

Nursing personnel			Medical personnel		
Item	Component 1	Component 2	Item	Component 1	Component 2
1	0.790	0.207	1	0.630	−0.637
2	0.727	0.084	2	0.600	−0.311
3	0.847	0.101	3	0.522	0.646
4	0.876	0.037	4	0.806	−0.015
5	0.768	−0.398	5	0.815	−0.040
6	0.897	−0.248	6	0.616	−0.151
7	0.785	0.110	7	0.769	0.137
8	0.452	0.830	8	0.700	0.177
9	0.912	−0.174	9	0.204	0.781
10	0.944	−0.126			

*Extraction method: principal component analysis without rotation.

Figure 1 Distribution of the answers to each item in the final scale.

in the NP.⁶ This does not invalidate the obtaining of a single model to record healthcare professionals' satisfaction, which in subsequent analysis may be stratified to determine satisfaction in both groups and how different factors or confounding variables may influence satisfaction in these groups.²¹

A high cut-off point was used to measure satisfaction with the CPOE system: to define a participant as satisfied, a mean score of 4 points per item was required in the questionnaire, regardless of the scale used. This decision was based on the similarity to patient satisfaction studies that show very high scores and on the results reported in previous studies.^{5 15 16 19 24 25}

Low satisfaction with the CPOE system is due to the lack of flexibility or the bureaucracy and workload that it involves, which explains the efforts made to improve its usability.^{10 11 23–25} Furthermore, different satisfaction levels over time have been detected in MP,¹⁷ as users can get used to CPOE or improvements have been introduced to facilitate their use.^{10 14 26}

A ceiling effect can be observed in the answers to each item of the scales, most concentrated in the higher values. This effect is reflected in the median item scores and indicates the low change sensitivity of the original scales used.²⁰ This effect is common and can be also observed in the answer pattern recorded in similar studies.^{5 15 25} Likewise, in a previous Spanish study,¹⁶ the answers to the questionnaire already showed this ceiling effect. When using the final model with our data, this effect is attenuated, but not avoided, as shown in figure 1.

We started from the hypothesis that satisfaction with a specific technological tool could be one dimensional, although some authors recommend considering more domains.²⁶ Different tools have been used to measure satisfaction with CPOE,¹⁵ most of which were developed by the researchers themselves.²⁴ Currently, there is only one tool considered to be strictly specific: POESUS (Physician Order Entry User Satisfaction and Usage Survey).¹⁵ In this study, we used a specific two-factor questionnaire created and used by Escolano *et al*¹⁶ in our healthcare setting and culture.

The item selection and refining process is intuitive and depends on the researcher's experience and criteria.²¹ On finding that many (seven) items were equal or almost equal in both original scales, they were directly merged or only slightly rephrased, as can be seen in online supplementary appendix 1. By refining the items, a final six-item scale was achieved with high reliability (Cronbach's $\alpha > 0.80$), good validity and a sample size large enough for each answered question (11 per item),²¹ which attenuated the ceiling effect detected in the original scales.

The results obtained in the MP questionnaire and in its factor analysis may be inconsistent for several reasons. For example, although the question about overall satisfaction (MP8) had greater weight, it is not the one with greatest influence on the first component. Also question MP9 about CPOE facilitating prescription had greater impact on the second component than on the first.²¹ It is possible that, because of the small number of MP in the hospital, they felt they were being observed, even though anonymity was guaranteed in this survey. Additionally, the meaning of each item may have been understood differently by MP and NP. It should be taken into account that there are benefits when introducing a CPOE system, and inherent risks, although the risk-benefit balance is highly favourable.^{9 12 26} This survey was conducted more than a year after the CPOE was introduced in the hospital in order to avoid the learning period.

One of the main limitations of this study, as previously mentioned, was the small sample used to determine the degree of satisfaction and to obtain a single questionnaire. The questionnaires used did not undergo a previous test-retest validation,

which is usually necessary to measure their validity.^{16 20} Another limitation is the lack of verification of item wording in a pilot study,²¹ although they were tested in a previous study.¹⁶ However, a single scale was finally obtained. This scale is reliable, valid, more flexible and with faster completion, facilitating its use in any type of healthcare institution. Nevertheless, it would be advisable to test this scale in other future surveys and/or other hospitals in order to confirm its validity.

CONCLUSIONS

The degree of satisfaction with the CPOE in a long-stay hospital was high, though lower among NP than MP. Obtaining a single questionnaire can facilitate the process of determining satisfaction with CPOE in healthcare institutions.

What this paper adds

What is already known on this subject

- Medication-related adverse events are common (approximately one-third of all adverse events related to healthcare) and preventable in almost 50% of cases.
- The implementation of active strategies to promote a patient safety culture is imperative. Computerised provider order entry (CPOE) systems reduce medication errors, but their acceptance by healthcare professionals is not always good.
- There are different questionnaires to assess healthcare personnel's satisfaction with CPOE, almost always with two variants, one for medical personnel (MP) and another for nursing personnel (NP).

What this study adds

- This study provides a single model of questionnaire to assess personnel satisfaction (MP and NP) with CPOE systems that simplifies and accelerates data collection, measurement and analysis.
- Our final six-item scale achieves high reliability, good validity and less ceiling effect than the original scales. Obtaining a single questionnaire can facilitate the process of determining satisfaction with CPOE in healthcare institutions.

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