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RISK ANALYSIS AND USER SATISFACTION AFTER IMPLEMENTATION OF COMPUTERIZED PHYSICIAN ORDER ENTRY IN DUTCH HOSPITALS

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ABSTRACT

Background: Computerized physician order entry (CPOE) in hospitals is widely considered to be important for patient safety, but the implementation is lagging behind, and user satisfaction is often low. Risk analysis methods may improve the implementation process and thus user satisfaction.

Objective: Our study aimed to determine the association of performing risk analysis with user satisfaction after implementation of CPOE.

Setting: All hospitals in the Netherlands.

Method: A cross-sectional study using a questionnaire was performed. All Dutch hospital pharmacies were asked about the extent of implementation of CPOE in the hospitals they served, the performance of (retrospective or prospective) risk analysis and the satisfaction with CPOE of doctors, nurses, and pharmacists. Only hospitals that had implemented inpatient CPOE on at least 70 percent of the wards were included in the primary analysis.

Main Outcome Measure: The primary outcome measure was the proportion of hospital pharmacists with a satisfaction level of 4 or 5 (i.e. 'satisfied'). The secondary outcome measure was the proportion of medical doctors and nurses with a satisfaction level of 4 or 5 (i.e., satisfied). The main determinant was the performance of a formal method of prospective or retrospective risk analysis.

Results: The questionnaire was sent to all 79 Dutch hospital pharmacies. Questionnaires were returned by 70 hospital pharmacies, serving 72 separate hospitals. In 40 hospitals the CPOE was implemented on at least 70% of the wards. The association of risk analysis with the proportion of satisfied users was determined within this group of 40 hospitals. For hospital pharmacists, we found that the performance of risk analysis showed a statistically non-significant trend towards an association with satisfaction (OR 3.3 (95% CI: 0.8-14.1)). For medical doctors, the performance of risk analysis was associated with satisfaction (OR 10.0 (95% CI 1.8-56.0)). Also, a statistically non-significant trend towards an association with satisfaction was found for nurses (OR 4.5 (95% CI: 0.8-24.7)).

Conclusion: Although not statistically significant, the user satisfaction with CPOE seems to be associated with the performance of risk analysis during the implementation of CPOE. This suggests that the CPOE implementation process can be optimized by performing a risk analysis before and / or after implementation.

Impact of findings on practice

- The majority of Dutch hospitals have implemented CPOE for 70% or more on nursing wards.
- The satisfaction of CPOE users seems to be positively associated with the performance of risk analysis.
- Risk analysis can optimize the implementation process of CPOE in hospitals.

INTRODUCTION

Electronic prescribing of medication or Computerized Physician Order Entry (CPOE), may contribute to the proper use of medication by hospital inpatients and the reduction of medication errors and patient harm ¹⁻⁷. In a review article on the effect of CPOE on medication errors, Reckmann et al. ⁸ described 12 studies of which 9 reported a significant reduction in medication errors. This reduction included all types of errors, such as prescription errors and transcription errors. In 2005 two studies ^{9,10} showed an increase in the perceived number of risks using CPOE and in medication errors and increased mortality associated with the new CPOE system in comparison with the old paper-based prescription system. In contrast, Van Doormaal et al. and Chen et al. ¹¹⁻¹³ showed that CPOE reduces the incidence of medication errors. Despite these conflicting results both healthcare professionals and healthcare authorities consider the use of CPOE as an essential element in the complex chain of safe use of drugs in hospitals ^{14,15}.

In many hospitals, CPOE is being implemented. However, medical doctors and other healthcare professionals indicate that CPOE systems do not always operate as desired or expected ^{16,17}. Usability problems occur, systems are considered time-consuming, immature and the cause of (new) errors or unintended consequences ¹⁸⁻²⁰. Much of the discontent, resistance, and unsafe use can be traced back to the poor implementation of the CPOE system, for example resulting from incompatibility with existing daily work procedures and routines ²¹. This may partly explain that despite the great potential of CPOE to improve quality of care and patient safety, implementation of CPOE is lagging behind. For example, in 2009 only 15-17% of the hospitals in The United States had a functional CPOE system available ^{22,23}. An implementation may be improved in several ways. Influencing tactics at the right time, in the right manner and by the right people (information technology leaders, leading clinicians) can be used in overcoming user resistance ^{24,25}, but limited effects are reported ²⁶. Also, risk analysis techniques before or after (prospective or retrospective) the implementation of a CPOE system can be used both as a safety improvement and as a tool in overcoming user resistance. Bonnabry ²⁷ used a Failure Modes, Effects and Criticality Analysis (FMECA) method ²⁸ in a study before and after the implementation of CPOE. This FMECA resulted in a significant risk reduction and was helpful in identifying additional system improvements. The aims of prospective risk analysis techniques are the identification of risks and subsequent measures to resolve such risks, ultimately resulting in the reduction of patient harm. FMECA [Williams et al. (1994)²⁹] and Healthcare Failure Mode and Effect Analysis (HFMEA) Habraken et al. (2009)³⁰ Stalhandske et al. (2003)³¹ are examples of this approach. HFMEA was developed by the United States Department of Veterans Affairs and the United States National Center for Patient Safety (NCPS)³² and is based on safety management of the manufacturing,

chemical and nuclear industries and civil aviation. FMEA is time-consuming and lacks validation, but by the multidisciplinary mapping process, it seems valuable also in health care. Retrospective risk analysis can be used to investigate incidents and outcomes can be used to improve the system^{33,34}. Key characteristics of prospective and retrospective risk analysis methods are shown in Figure 1 (Franklin et al.)³⁵. Applying prospective or retrospective risk analysis before, and / or after CPOE implementation may lead to increased satisfaction of healthcare workers with CPOE and its implementation, but little evidence on this assumption is available. To our knowledge, no study has previously explored the possible association of prospective or retrospective risk analysis with the satisfaction of healthcare workers after implementation of CPOE.

AIM OF THE STUDY

The primary aim was to investigate whether performing prospective or retrospective risk analysis during the implementation of CPOE is associated with CPOE satisfaction of hospital pharmacists. Secondary aims were to investigate the associations of performing that risk analysis with CPOE satisfaction of medical doctors and nursing staff.

METHOD

A cross-sectional study was performed using a structured questionnaire that was sent to all hospital pharmacies in the Netherlands (Appendix 1). The development and design of the questionnaire were based on the 2010 version of "Questionnaire Development" (Statistics Netherlands)³⁶. A pilot was conducted in 5 hospitals to test the initial questionnaire. Following the answers, the questionnaire was slightly modified (streamlining some questions). Appendix 1 shows the full questionnaire (translated from Dutch). The questionnaires were sent in February 2011 and after the first mailing two reminders were sent (in May and June 2011).

Study participants

In the Netherlands, the hospital pharmacist is legally co-responsible for delivering health care and be held accountable for proper and safe medication processes in hospitals. Consequently, the Dutch hospital pharmacists took the lead in implementing electronic medication management systems, including CPOE. The hospital information technology department only facilitates the use of these systems and supports the infrastructure and the hardware. For this reason, the questionnaire was sent to all 79 Dutch hospital pharmacies serving eight university hospitals, 26 teaching hospitals, and 50 general hospitals. It was addressed to hospital pharmacists known to be responsible for the information technology aspects of the hospital pharmacy. If this function was not assigned to a hospital pharmacist, the questionnaire was sent to the head of the hospital pharmacy department for completing the questionnaire. Specialized hospitals and psychiatric hospitals were not included in the survey.

Data collection

We designed a structured questionnaire asking about five different topics:

1. General questions about the hospital and the hospital pharmacy.
2. Questions on the safety culture in the hospital and the hospital pharmacy (e.g., whether or not the hospital participated in error reporting programs, applied safety analysis).
3. Questions on the presence of an inpatient computerized physician order entry system (CPOE) and degree of implementation on the wards. We distinguished three (arbitrary) implementation situations: CPOE used on less than 30% of the wards, between 30 and 69% and on more than 70% of the wards.
4. Questions on the performance and methods of prospective [e.g., Bow-Tie method (Wierenga et al.³⁷, and Hudson and Guchelaar³⁸), HFMEA method [Kessels-Habraken et al.³⁹] and retrospective risk analysis [e.g. Root Cause Analysis as SIRE, Systematic Incident Reconstruction and Evaluation method (Percarpio et al.⁴⁰, and Amo⁴¹) or PRISMA-medical, Prevention and Recovery Information System for Monitoring and Analysis [Snijders et al.⁴²] before and after implementation of CPOE.

- 5 Questions on the satisfaction of the users (doctors, pharmacists, nurses) as perceived by the pharmacist, indicated on a Likert scale ⁴³ of 1 to 5 (1 = very dissatisfied, 5 = very satisfied, in this study 4 and 5 was regarded as satisfied). In Dutch hospitals, the hospital pharmacists, as well as the medical doctors, are a member of the hospital medical staff. Members of the medical staff in hospitals in the Netherlands are those academic healthcare workers who are (co-) responsible for health care delivery to patients. So, unlike many other countries, they are direct colleagues of the medical doctor. For that reason, hospital pharmacists are usually very well aware of the opinions of the medical doctor. Therefore, the hospital pharmacists were asked to indicate the level of perceived satisfaction of the medical doctor with the CPOE system used in the hospitals they served. Pharmacists and pharmacy technicians are also in close contact with the nursing staff on the wards, e.g., checking patient's medication on admission or being involved in discharge planning. The Dutch hospital pharmacists are therefore also aware of the views of nurses and their (perceived) satisfaction with the CPOE system. As both the satisfaction of doctors and nurses is measured by asking for their perceived satisfaction by the hospital pharmacist, these outcomes were only included as secondary outcome measures.

Only hospitals with a degree of implementation of CPOE was 70% or more were included in the study, to make sure that the answers regarding satisfaction of healthcare workers reflected most of the hospital.

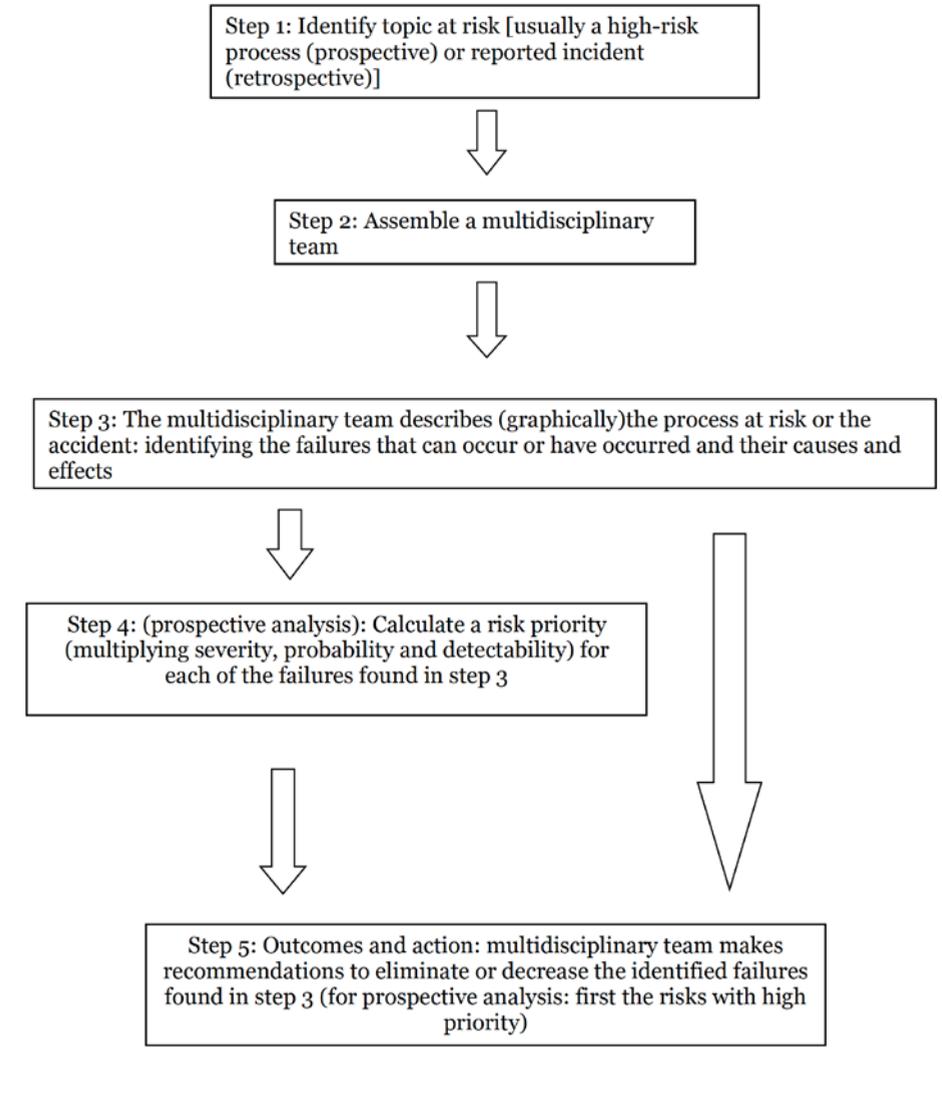
Outcome measures

The primary outcome measure was the proportion of the pharmacists with a satisfaction level of 4 or 5 on a 5-point Likert scale (i.e. 'satisfied'). The secondary outcome was the proportion of other users (medical doctors and nurses) of the CPOE with a satisfaction level of 4 or 5 on a 5-point Likert scale (i.e. 'satisfied'). The main determinant was the performance of a formal method of prospective or retrospective risk analysis.

Data analysis

All data were entered using MS Excel 2010. Data were analyzed using statistical software (SPSS, version 18; SPSS Inc. Chicago, Illinois). The association between the performance of prospective risk analysis and the satisfaction of the users was determined by univariate logistic regression analysis.

Figure 1. Key characteristics of prospective and retrospective risk analysis methods



RESULTS

The questionnaire was sent to 79 hospital pharmacies. Initially, we received 56 questionnaires back and another 14 after sending reminders. So, in total 70 hospital pharmacies (serving 72 independent hospitals (out of 84)) returned the questionnaires. All these questionnaires are included in our study. Nine of the questionnaires were not sent back: one of them from a university hospital pharmacy, two from the pharmacy of teaching hospitals and six from the pharmacy of general hospitals (in total serving 12 hospitals).

CPOE was used or being implemented by 64 of these 72 hospitals. In the hospitals ten different CPOE systems were used, seven commercially available systems and three systems built by the IT department of the hospital. No dominance was seen in the commercially available CPOE systems. The characteristics of the responding hospitals are shown in table 1.

Table 1. Characteristics of the responding hospital's pharmacies

Characteristics	University hospitals	Teaching hospitals	General hospitals	All hospitals
Number of hospitals	7	24	41	72
Number of hospital beds				
• mean	1032	826	415	612
• range	715-1479	450-1300	200-1000	200-1479
	N (%)	N (%)	N (%)	N (%)
Hospital safety culture				
• in hospital error reporting	7 (100%)	24 (100%)	41 (100%)	72 (100%)
• in hospital error analyzing	5 (71%)	21 (88%)	35 (85%)	61 (85%)
• nationwide error reporting program member	4 (57%)	19 (79%)	34 (83%)	57 (79%)
% of implementation of CPOE on wards				
• No CPOE or startup	0 (0%)	4 (17%)	12 (29%)	16 (22%)
• 0%-29%	0 (0%)	3 (13%)	6 (15%)	9 (13%)
• 30%-69%	0 (0%)	2 (8%)	5 (12%)	7 (10%)
• 70%-100%	7 (100%)	15 (63%)	18 (44%)	40 (56%)

The extent to which CPOE was used varied: 40 hospitals used a CPOE system in 70% or more of the wards while 32 hospitals did not or only partly used a CPOE system. The association of the performance of (retrospective or prospective) risk-analysis with the proportion of satisfied users was determined within this group of 40 hospitals.

For hospital pharmacists, a non-statistical trend towards an association with satisfaction was found [odds ratio (OR) 3.3, 95% confidence interval (95% CI) 0.8-14.1]. For medical doctors, the performance of risk-analysis was associated with satisfaction [OR 10.0, (95% CI 1.8-56.0)], while for nurses a non-statistical trend towards an association with satisfaction was found [OR 4.5, (95% CI 0.8-24.7)], (Table 2).

Table 2. Association of risk analysis with CPOE satisfaction of hospital pharmacists, doctors and nurses for hospitals with 70% or more implementation of CPOE on nursing wards_

	Satisfied N (%)	Dissatisfied N (%)	OR ^a (95% CI ^b)
Hospital pharmacists			
No risk analysis performed	10 (59)	19 (83)	Ref. ^c
Risk analysis performed	7 (41)	4 (17)	3.3 (0.8-14.1)
Medical doctors			
No risk analysis performed	9 (50)	20 (91)	Ref. ^c
Risk analysis performed	9 (50)	2 (9)	10.0 (1.8-56.0)
Nurses ^d			
No risk analysis performed	14 (61)	14 (83)	Ref. ^c
Risk analysis performed	9 (39)	2 (13)	4.5 (0.8-24.7)

^a OR = Odds ratio

^b CI = Confidence Interval

^c Ref. = Reference category

^d One missing value

DISCUSSION

Our study showed a non-statistically significant trend to the association between performing prospective or retrospective risk analysis on the implementation of CPOE systems and user satisfaction for hospital pharmacists (primary outcome). For medical doctors (secondary outcome) this association was statistically significant (perceived user satisfaction). For the user group nurses (also secondary outcome) a non-statistical trend to (perceived) user satisfaction was identified. Few studies have addressed the association between prospective or retrospective risk analysis and user satisfaction. Apkon et al. (2004)⁴⁴ redesigned the process of prescribing and delivering of continuous drug infusions using CPOE instead of a paper-based system. They performed a failure modes and effects analysis (FMEA) as part of the implementation process. Both physicians and nurses were satisfied with the revised process, measured on a 5-point Likert scale. However, it was not possible to determine the association between FMEA and satisfaction, because of the lack of a control group not using FMEA.

Implementation of a new and radical process change such as CPOE that involves many health care professionals requires a careful approach. Changes in care processes must be accepted by the professionals who have to work in the new setting. From the results of our questionnaire, we concluded that the majority of the pharmacists and the medical doctors were not content with the implemented CPOE system. Dissatisfaction can be caused by many factors such as technical difficulties, software and layout problems, increased sensitivity to error and failure to implement a safe CPOE as part of an integrated system within the daily workflow on the ward. Though no evidence is available on this subject, performing a prospective or retrospective risk analysis may help to prevent such dissatisfaction, but in Dutch hospitals - in contrast to the chemical industry or the aviation industry - the performance of prospective risk analyses is not customary. Our research shows that risk assessments within hospitals around the implementation of new and complex procedures and techniques can potentially contribute to user satisfaction regarding these procedures and techniques.

A few limitations of our study need to be addressed. First, most Dutch hospital pharmacies participated in our research, but this is globally a relatively small group of hospitals. CPOE is implemented in several western countries sometimes with ambiguous results (Aarts and Koppel, (2009)⁴⁵. The findings of our study, therefore, may not be applicable to hospitals in other countries. Second, a major limitation of our cross-sectional study design is that apart from the differences we want to measure other differences may determine the outcomes. Third, a causal relationship is unclear because potential cause and effect are measured at the same point in time. Furthermore, because of the limited sample size, we could only

perform the univariate analysis. Therefore, the identified association may alter when it is adjusted for potential confounders. A final limitation is the fact that a single hospital pharmacist (either head of the department or IT specialist pharmacist) was questioned about the opinion of the physicians, the nurses, and other pharmacists. It is not sure this is a proper reflection of the point of view of these professionals. More research has to be done to clarify these issues.

Notwithstanding these limitations, our study is the first that investigated the potential association of risk analysis and user satisfaction. Risk assessments can provide essential insight into the critical aspects of a work process preventing a failure condition or into a safety issue diagnosed in the risk assessment. Consequently, risk analysis can contribute to user satisfaction and thus the performance of risk analysis before and / or after the implementation of CPOE is recommended. However, future studies are necessary to determine satisfaction expressed directly by the specific user groups (instead of questioning only hospital pharmacists) and into other measures of successful implementation. Such research may ultimately aid in rendering CPOE the safety tool it is designed to be.

CONCLUSION

Our study identified a trend towards an association of risk analysis with the satisfaction of hospital pharmacists after implementation of a CPOE. As a secondary outcome, our study identified an association of risk analysis with (perceived) satisfaction for medical doctors and potentially for nurses after implementation of CPOE. In order to increase user satisfaction, the performance of formal methods of risk analysis around implementation of CPOE may be recommended, but further studies are needed to draw definite conclusions on this subject.

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APPENDIX 1

The questionnaire used in the study (translated from Dutch)

About the Hospital Pharmacy:

Name Hospital / Hospital Pharmacy:
City:
Number of hospitals the hospital pharmacy is responsible for:
Hospital size in inpatients:
Number of nursing homes the hospital pharmacy is responsible for:
Nursing home size in inpatients:
Number of other institutions the hospital pharmacy is responsible for (e.g., specialized hospitals):
Number and Type:
Institution size in inpatients:

About the Department of hospital pharmacy and pharmaceutical staff:

Full positions hospital pharmacists:
Full positions pharmacists:
Full positions interns:
Full positions (hospital) pharmacist concerning ICT:
Full positions software application manager:
Full positions hardware system administrator:
Full positions technicians involved in clinical pharmaceutical care:

About the Hospital Safety Culture:

Error reporting and registration: (multiple answers possible):

- Hospital management
- Safety management system committee (VMS)
- Errors and near accidents committee (FONA)
- Incident reporting committee (MIP)
- Safe error reporting committee (VIM)
- Another reporting system:
- There are no error reporting systems / we do not report errors (circle the correct answer)

Is a retrospective risk assessment with analysis of reported errors? (multiple answers possible):

- yes by Prevention and Recovery Information System for Monitoring and Analysis (PRISMA)
- yes by Systematic Incident Reconstruction and Evaluation (SIRE)
- yes using another method, namely:
- no

The hospital pharmacy has experience in performing prospective risk assessment (multiple answers possible):

- yes with Scenario Analysis of Failure Modes Effects and Risks HFMEA/SAFER
- yes with Bow Tie
- yes with another method namely:

The hospital pharmacy participates in the Dutch nationwide error reporting system CMR (Central Registration of Medication Incidents):

- yes, more than 10 reports per year
- yes, less than 10 reports per year
- no

The hospital pharmacy has experience with formal measurement of medication errors, e.g., by checking medication orders for spelling mistakes or 'disguised observation' for the mapping of administration errors:

- yes namely:
- no

About the CPOE system:

Is a CPOE system in the hospital present?

- yes for both inpatients and outpatients
- yes for inpatients only
- yes for both inpatients and outpatients and integrated into an EMR (Electronic Medical Record)
- yes for inpatients only and integrated into an EMR (Electronic Medical Record)
- yes for outpatients only and integrated into an EMR (Electronic Medical Record)
- no there is no CPOE system in our hospital

If the hospital has a CPOE system present, to what extent is this implemented? (multiple answers possible):

- % on (inpatient) wards
- % for outpatients.....
- % on the Intensive care / cardiac care units
- % in the operating theater complex

Is a CPOE system in the nursing homes / other institutions present?

- yes in the nursing homes and other institutions as well
- yes in the nursing homes only
- yes in the other institutions only
- no

If the nursing homes / other institutions have a CPOE system present, to what extent is this implemented? (multiple answers possible):

- % nursing homes
- % other institutions
- no there is no CPOE system in the nursing homes and other institutions

Who is prescribing medication in the CPOE system (multiple answers possible)?

- specialized medical doctors
- medical doctors
- interns / physician assistants (whether or not in training)
- specialized nurses
- nurses
- hospital pharmacists
- pharmacists
- pharmacy technicians
- others, namely:

Which (commercial / non-commercial) CPOE system is in use?

- Medicator
- Klinikom
- ROSS Health Pharma
- Theriak
- Centrasys
- Chipsoft
- Isoft
- Alert
- Other system / DIY (non-commercial):

Did you prepare a User Requirement Specification (URS) in the process of selection and purchase or construction of the CPOE software?

- yes
- no

Is the CPOE software in use validated?

- yes by the Good Automated Manufacturing Practice (GAMP5) method
- yes using another method namely:
- no

System procedures and SOPs regarding the use of the CPOE system are drafted (multiple answers possible):

- no there are no established procedures and SOPs
- yes by the hospital pharmacy
- yes by the medical doctors
- yes by the managers of the ward
- yes by the nurses of the ward
- yes by the manufacturer of the CPOE system
- yes by others namely:

Did you carry out a prospective risk assessment before implementation of the CPOE system?

- yes by HFMEA / SAFER method
- yes by Bow Tie method
- yes by another method namely:
- no

If yes: what was the outcome of the prospective risk assessment:

- change in the type of risks namely:.....
- change in the number of risks, i.e. more / less (circle the correct answer)
- no change in type or number

What was the timeframe of the prospective risk assessment?

- n.a.
- < 3 months
- 3-6 months
- > 6 months

Did you carry out a retrospective risk assessment before implementation of the CPOE system?

- yes by PRISMA method
- yes by SIRE method
- yes by another method namely:
- no

If yes: what was the outcome of the retrospective risk assessment:

- shift in the type of errors namely:
- shift in the number of errors, i.e., more / less (circle the correct answer)
- no shift in type or number

What was the timeframe of the retrospective risk assessment?

- n.a.
- < 3 months
- 3-6 months
- > 6 months

Did you carry out a formal check for prescription errors before implementation of the CPOE system? (For example, during a given period all medication orders are checked for errors).

- yes
- no

Did you carry out a formal check for prescription errors after implementation of the CPOE system? (For example, during a given period all medication orders are checked for errors).

- yes
- no

If yes: what was the outcome of the formal measurement of prescription errors:

- we found new or uncommon errors namely:
- shift in the type of errors namely:
- shift in the number of errors namely more / less (circle the correct answer)
- no differences were measured

What was the timeframe of the formal measurement of prescription errors?

- n.a.
- < 3 months
- 3-6 months
- > 6 months

About the CPOE system and the satisfaction of the users:

The hospital pharmacy is satisfied with the CPOE:

On a scale of 1 to 5 (1 = very dissatisfied, 5 = very satisfied, (circle the correct number on the scale)):

1----2----3----4----5

Please explain your answer:

.....

The medical doctors are satisfied with the CPOE:

On a scale of 1 to 5 (1 = very dissatisfied, 5 = very satisfied, (circle the correct number on the scale)):

1----2----3----4----5

Please explain your answer:

.....

The nurses are satisfied with the CPOE:

On a scale of 1 to 5 (1 = very dissatisfied, 5 = very satisfied, (circle the correct number on the scale)):

1----2----3----4----5

Please explain your answer:

.....

The management of the hospital is satisfied with the CPOE:

On a scale of 1 to 5 (1 = very dissatisfied, 5 = very satisfied, (circle the correct number on the scale)):

1-----2-----3-----4-----5

Please explain your answer:

.....

The timeframe for general acceptance of the CPOE system for all users after:

- < 3 months
- 3-6 months
- > 6 months

Final Question

Have you missed a question or is there a test method which is not touched upon? Do you have any other remarks about this questionnaire?

.....

Thank you!

