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RESEARCH ARTICLE

EVALUATION OF THE EFFICACY OF ENHANCED COMPUTERISED ORDER ENTRY (COE) WITH AN EMBEDDED CLINICAL DECISION SUPPORT (CDS) IN A TERTIARY CARE HOSPITAL SETTING

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ABSTRACT

Objective: Computerized order entry System (COE) with embedded clinical decision support (CDS) can check doses during prescription order entry along with the name of the drug, category, formulations available, indication, doses, drug interactions, contra-indications, side effects and special monitoring. The study was designed to develop a COE enhanced with CDS, to evaluate the efficacy and preconceived physicians' attitude towards COE with CDS in a tertiary care hospital setting.

Method: The developed COE system with CDS was implemented in the hospital setting and totally 40 prescriptions were randomly selected from medical departments and analysed simultaneously by both COE with CDS and by the existing manual prescription order entry system. 40 physicians were randomly chosen and were oriented to the software initially and the preconceived physician's attitude towards COE with CDS in comparison with the existing system of prescription auditing was assessed using the first part of Physician Order Entry User Satisfaction and Usage Survey (POESUS).

Results: COE with CDS was statistically more efficient in identifying the alerts when compared to the existing order entry system. The time taken by the COE with CDS was not significantly different from the time taken by the existing system (P= 0.79).90% physicians had an overall satisfaction on COE with CDS system, 95% felt an overall improvement in safety of patient care and 75% physicians felt that COE system saved their time.

Conclusion: This study suggests that implementation of COE with CDS could improve patient safety, reduce medication related problems and save physicians' time.

INTRODUCTION

Patient safety practice is defined as the type of process or structure whose application reduces the probability of adverse events resulting from exposure to the health care system across a range of diseases and procedures. In the last four decades, patient care has been enhanced by advances in drug therapy but also has led to a noticeable increase in the incidence of drug related problems (DRP). Studies conducted in developed countries have reported an approximate of 5% of all hospital admissions as drug related, of which 50% of them were avoidable [1]. Appropriate dosing of medications is to make sure that patients receive neither excessive toxic doses nor the sub therapeutic low doses. Implementation of electronic prescribing systems such as computerized order entry (COE) with embedded clinical decision support system (CDS) in hospital can ensure prescribing of appropriate doses during prescription order entry besides the drug name, category, formulations available, indication, doses, drug interactions, contra-indications, side effects and special monitoring. COE with CDS would also display alerts when prescribed doses are out of range, can reduce ADE, medication errors by ensuring that prescriptions are entered completely and unambiguously and by warning of possible problems such as drug interactions and excessive doses [2]. The salient part of pharmaceutical care process is identifying, preventing and resolving Drug Related Problems (DRP). Because DRP has been detected in more systematic way, there is a need for a complete database to refer, prescribe and document. Though COE systems have the potential to improve patient outcomes by decreasing adverse drug events, the actual improvement in medical outcomes have not been documented. Though studies performed in 1970s and 1980s with COE systems dealt only with antibiotic administration by COE, however they proved to be beneficial both in cost saving and patient outcomes [3].

Medication errors can be potentially reduced and patient safety can be improved by Clinical information systems like

computerized physician order entry (CPOE). Especially the automated clinical decision support systems when embedded within the COE systems have proven to contribute significantly to medication error reduction through timely recommendations and monitoring for potential drug allergies, drug-drug interactions or overdosing. These warnings are termed as order checks and are displayed to the prescribers or other health practitioners at the time of prescription orders entry [4]. However because of the high cost involved in the development of these technologies, implementation of a CPOE with clinical decision support is less effective in India [5].

Existing prescription ordering system without CDS and computerized order entry with CDS are shown in figures 1 and 2. A study was conducted to develop a complete drug database for computerized order entry (COE) within the tertiary care teaching hospital setting which clearly describes the drug profile and their available brands, indications & side effects of a particular drug and cover all relevant processes of a drug therapy in the hospital setting i.e. prescribing, dispensing and drug use, to evaluate the enhanced COE with CDS efficacy in clinical setting and to assess the preconceived physicians' attitude towards COE with CDS by an end-user satisfaction questionnaire.

MATERIALS AND METHODS

Development of Database

Database is a structured set of data held in a computer, especially one that is accessible in various ways. Database Management System (DBMS) are specially designed software applications that interact with the user, other applications, and the database itself to capture and analyze the data and some well known DBMSs include My SQL, MariaDB, PostgreSQL, SQLite, Microsoft SQL server, Oracle, SAP HANA, dBASE, FoxPro, IBM DB2, Alpha Five FileMaker Pro, MemSQL, Informix, UniVerse and Panorama. The software was designed using Microsoft Sequential Query language Server for the development of the database entry programme and comprehensive drug data entry was made.

Stage: 1 - Selection of drug by its generic name and entry of its pharmacological category, fixed combinations of the selected drug, its route of administration and dosage form of the drug.

Stage: 2 - Entry of route of administration, formulation, available strengths, maximum doses of the selected drug.

Stage: 3 - Entry of dosage adjustment in patients with renal impairment based on creatinine clearance, hepatic impairment, dialysis, drug food interaction, pregnancy risk category (A= no evidence of risk, B= Safety data not established, C= Potential benefit justifies the potential risk to the foetus, D= Drug can be considered only in a life threatening situations, X= demonstrated foetal abnormalities- strictly contraindicated) lactation warning and special monitoring indication (biochemical data) for the selected generic drug.

Stage: 4 - Entry of drug – drug interactions by categorizing them as "Risk D" indicating need for modification of drug regimen, "Risk X" indicating strictly contraindicated.

Stage: 5 - The overall data entered for a particular drug can be viewed in a single window for verification.

Stage: 6 - Selection of generic name of the drug and mapping of brand names of the drug to the corresponding formulation which are available in the drug formulary.

Software coding

Source codes were given for retrieval of data from SQL for warning pop ups like individual drug allergy checking, group allergy checking, drug duplication alert, therapeutic duplication alert, pregnancy alert, lactation alert, hepatic alert, dialysis warning**,** renal alert, maximum dosage alert, drug interaction alert, high alert, look alike, sound alike, restricted drug alert.

Stages of COE entry in hospital setting

Sequence of COE entry was as follows: first, Entry of patients' identity in its respective field, capturing of individual drug allergy and blocking it during transcription, capturing of individual drug allergy and display of warning pop-up for the other drugs in the same category during transcription, capturing of group allergy and blocking it during transcription, pregnancy warning, lactation warning, dialysis warning,renal warning, hepatic warning, drug interaction alert, high alert, look alike, sound alike, drug duplication alert, therapeutic duplication alert and restricted drugs warning.

Evaluating the efficacy of the Enhanced COE with CDS

As a trial version, the developed computerized order entry system with CDS was implemented in the hospital setting and totally 40 prescriptions were randomly selected from various medical departments including general medicine, nephrology, neurology, oncology, pulmonology, psychiatry, cardiology and accident and emergency medicine and then the prescriptions were analysed simultaneously by both the COE with CDS and by the existing order entry system. Then the results obtained from both the systems were analyzed statically using SPSS version 16.0.

Assessment of Preconceived Physician's Attitude Towards COE with CDS by POESUS [6]

The original Physician Order Entry User Satisfaction and Usage Survey (POESUS) questionnaire consists of three parts with 27 questions in part 1, 3 questions in part 2 and 5 questions in part 3. Of the 27 Questions of part 1, questions 1 to 16 reflects on the end user satisfaction and hence these were used to assess the practicality and user friendliness of COE with CDS in comparison with the existing system of prescription auditing. In the present study, 40 physicians were randomly chosen from various medical departments and were categorized based on their clinical experience as senior doctors (experience>5years), Residents (experience<5years) and Postgraduates. Physicians were oriented to the software initially and were asked to use the system and then to answer the POESUS questionnaire.

Statistical analysis

The collected data was analysed with SPSS 16.0 version. Categorical variables were expressed by frequency analysis and percentage analysis and the continuous variables were expressed as mean and standard deviation. The efficacy of the enhanced COE over the existing order entry was assessed using MC Nemars test. The significant difference between the time taken for the COE with CDS and the existing order entry system to analyze a prescription was assessed using paired

sample t-test. The significant difference in responses given by the physicians of different designation for the questionnaire was assessed using chi-square test. The probability value 0.05 was considered as significant level for all the above statistical tools.

RESULTS

A statistically significant difference was observed between COE with CDS and the existing order entry system in identifying drug duplication alerts (9 by COE with CDS and 2 by existing system; P=0.02); maximum dosage alert (12 by COE with CDS and 3 by existing; P=0.007); drug interaction alerts (26 by COE with CDS and 4 by existing; P=0.0001); but there was no statistical difference between COE with CDS and existing system in identifying allergy alert; hepatic alert (P=0.3) lactation alert(P= 1.000); therapeutic duplication alert (P= 0.13); renal alert (P=0.24); dialysis warning (P= 0.48); pregnancy alerts(P= 0.48) which was depicted in table 1. The mean time taken to identify the afore mentioned alerts by COE with CDS was 1.53 ± 1.08 minutes and by the existing system was 1.50 ± 1.22 minutes per prescription. There was no statistically significant difference (P=0.79) between the two systems with respect to the time (Table 2).

Table 1 Alerts identified by Enhanced COE with CDS vs Existing system

Alerts	COE with CDS (N=40)	Existing System (N=40)	Significance P
Allergy alert	3	3	-
Drug duplication alert	9	2	0.02*
Hepatic alert	4	1	0.3
Lactation alert	2	1	1.000
Maximum dosage alert	12	3	0.007*
Drug interaction alert	26	4	0.0001**
Therapeutic duplication	4	0	0.13
Renal alert	3	0	0.24
Dialysis warning	2	0	0.48
Pregnancy alert	2	0	0.48

** A P value of <0.01 was considered highly significant

Table 2 Time Taken by the COE with CDS Vs Existing System

System	Total No of Prescriptions(N=40) Meantime ± SD (Min)	Significance P
COE with CDS	1.53 ± 1.08	
Existing System (Manual)	1.50 ± 1.22	0.79

A P value of <0.05 was considered statistically significant

The end user satisfaction of the COE with CDS was analyzed based on the responses given by 40 physicians, comprising of 17 (42.5%) senior doctors, 11 (22.5%) residents and 12(30%) postgraduates. Table 3 depicts the responses given by the respondents for the 16 questions of POESUS questionnaire.

For “Reliability of order entry system” (Q1) the responses were 2.5% for never, 12.5 % for it varies and 85% for always. There were no statistically significant differences in the responses based on the designation of the respondents (P=0.40).

For “Improvement in productivity” (Q2) the responses were 7.5% for never, 10 % for it varies and 82.5% for always. The designation of the respondents had no significant influence over the responses (P=0.4).

For “negative impact on patient care system” (Q3) the responses were 80% for never, 7.5 % for it varies and 12.5% for always, with no statistically significant difference in the responses (P=0.08).

For “reduction in patient care errors”(Q4) the responses were 10% for never, 5 % for it varies and 85% for always. There were no statistically significant differences in the responses based on the designation of the respondents (P=0.14).

For “the order entry system is easy to use” (Q5) the responses were 5% for never, 10 % for it varies and 85% for always. The designation of the respondents had no significant influence over the responses (P=0.3).

For “compared to paper ordering, order entry slows me down “(Q6) the responses were 50% for never, 7.5 % for it varies and 32.5% for always, with no statistically significant difference in the responses (P=0.95).

For “Information provided by the order entry to write better orders” (Q7) the responses were 2.5% for never, 2.5 % for it varies and 95% for always. There were no statistically significant differences in the responses based on the designation of the respondents (P=0.23).

For “adequate training on order entry” (Q8) the responses were 12.5% for never, 7.5 % for it varies and 80% for always. The designation of the respondents had no significant influence over the responses (P=0.95).

For “Improvement in the quality of patient care” (Q9) the responses were 5% for never and 95% for always, with no statistically significant difference in the responses (P=0.45).
For “System response time on order entry is slow” (Q10) the responses were 40 % for never, 22.5 % for it varies and 37.5% for always. There were no statistically significant differences in the responses based on the designation of the respondents (P=0.79).

For “seeking help for order entry” (Q11) the responses were 15% for never, 10 % for it varies and 75% for always. The designation of the respondents had no significant influence over the responses (P=0.81).

For “Benefits from refresher classes on order entry” (Q12) the responses were 7.5% for never, 12.5 % for it varies and 80% for always, with no statistically significant difference in the responses (P=0.63).

For “help on order entry” (Q13) the responses were 10% for never, 10 % for it varies and 80% for always. There were no statistically significant differences in the responses based on the designation of the respondents (P=0.16).

For “overall, improvement in safety of patient care” (Q14) the responses were 5 % for it varies and 95% for always. The designation of the respondents had no significant influence over the responses (P=0.45).

For “overall, order entry saves me time” (Q15) the responses were 10% for never, 15 % for it varies and 75% for always, with no statistically significant difference in the responses (P=0.22).

For “overall, satisfaction with the order entry system” (Q16) the responses were 10 % for it varies and 90% for always. There were no statistically significant differences in the responses based on the designation of the respondents (P=0.19).

Table 3 Physicians' Responses to POESUS Questions

	Question	Never (%)	It varies (%)	Always (%)	Significance P
1	Reliability of order entry system	2.5	12.5	85	0.40
2	Improvement in productivity	7.5	10	82.5	0.4
3	negative impact on patient care	80	7.5	12.5	0.08
4	reduction in patient care errors	10	5	85	0.14
5	The order entry system is easy to use	5	10	85	0.3
6	compared to paper ordering, order entry slows me down	50	17.5	32.5	0.95
7	Information provided by the order entry to write better orders	2.5	2.5	95	0.23
8	for adequate training on order entry	12.5	7.5	80	0.95
9	Improvement in the quality of patient care	5	0	95	0.45
10	System response time on order entry is slow	40	22.5	37.5	0.79
11	seeking help for order entry	15	10	75	0.81
12	Benefits from refresher classes on order entry	7.5	12.5	80	0.63
13	help on order entry	10	10	80	0.16
14	overall, improvement in safety of patient care	0	5	95	0.45
15	order entry saves me time	10	15	75	0.22
16	overall, satisfaction with the order entry system	0	10	90	0.19

A P value < 0.05 was considered statistically significant

Table 4 explains the association between responses 2 and 16, 9 and 16, 3 and 9, 6 and 15, 7 and 14 of POESUS questionnaire. A statistically significant association was observed between Q2 "Improvement in productivity" and Q16 "Overall, satisfaction with the order entry system" (P= 0.003); between Q7 Information provided by the order entry to write better orders and Q14 "Overall, improvement in the safety of patient care" (P=0.0001); between Q6 "compared to paper ordering, order entry slows me down" and Q15 "Overall, order entry saves me time" (P=0.008); between Q9 "Improvement in the Quality of patient care" and Q16 (P =0.008). There was no statistically significant association between Q3 "Negative impact on patient care" and Q9 (P=0.25).

Table 4 Association between Responses

Question Numbers	Significance (P)
Q2*Q16	0.003**
Q9*Q16	<0.0001**
Q3*Q9	0.251
Q6*Q15	0.008*
Q7*Q14	<0.0001**

** A P value of <0.01 was considered highly significant

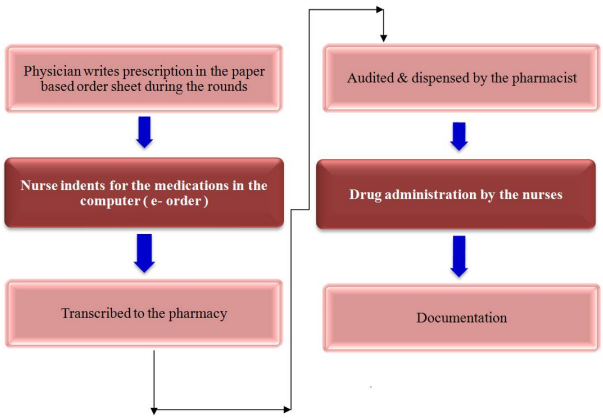

Figure 1 Existing Prescription Ordering System without CDS

DISCUSSION

This study was conducted to develop a COE with CDS and compare the efficacy of it with existing order entry system. Out of 40 prescriptions analyzed from various departments, COE with CDS identified 9 drug duplication alerts, 4 hepatic

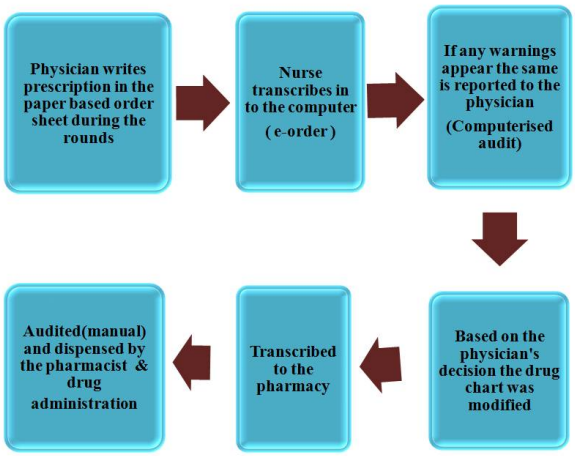

Figure 2 COE with CDS

alerts, 2 lactation alerts, 12 maximum dosage alerts and 26 drug interactions alert, 4 therapeutic duplication alerts, 3 renal alerts, 2 dialysis warning, 2 pregnancy alerts and the existing system identified only 2, 1, 1, 3, 4 of the former five alerts respectively and none of the later four alerts. Even though, comparison of the efficacy of both the systems showed a statistical significance only for drug duplication, drug interactions and maximum dosage alerts, the COE with CDS is more efficient in identifying all the alerts when compared to the existing system. This finding is in concordance with the study done by Teryl K Nuckols, *et al*, which depicted the efficacy of CPOE in reduction of preventable adverse drug events or medication errors [7]**.** Radley and colleagues also found that the medication errors declined by about half with CPOE implementation [8].

Gilad J Kuperman, *et al*, have suggested that CPOE with CDS improves medication safety and reduce medication related errors [9]. As the COE has already been captured with data that are critical for CDS such as patients' age, weight, allergy status, serum creatinine, pregnancy, lactation, dosage adjustment in hepatic and renal disease, dialysis, the COE with CDS is more capable in detecting alerts and provide clear concise and accurate drug related warning than the existing system which has to check for the above alerts manually to detect them where there are possibilities of error.

The time taken by the COE with CDS was not significantly different from the time taken by the existing system.in

ordering and analysing prescriptions, despite being assumed that the COE with CDS may take more time due to many interruptions like pop up warnings.

The present study also assessed the preconceived physician attitude towards COE with CDS by using physician order entry user satisfaction and usage survey (POESUS) questionnaire on end user satisfaction in 40 physicians comprising of 17 senior doctors, 11 residents and 12 post graduates. Irrespective of their designation 90% of physicians had an overall satisfaction with COE and 95% of them felt overall improvement in safety of patient care, 75% of physician felt that COE system saved their time. A study conducted by Lee *et al* [6] using POESUS questionnaire to compare the end user satisfaction of the physicians and nurses over CPOE also identified that users were generally satisfied with CPOE. They also observed that physicians were more satisfied than nurses and medical doctors were more satisfied than surgical doctors. But the responses of the doctors suggested that that they spent more time in ordering prescriptions through CPOE and the efficacy of COE was more strongly associated with user satisfaction than quality of patient care. In contrary to this report, in the present study more than 80% of the physicians responded positive for both user friendliness of COE and its role in improvement of patient care and more than 75% of physicians responded that COE saved their time when compared to paper order entry.

The present study also attempted to evaluate the relevance of the responses given by the respondents by assessing the significant association between improvement in productivity (Q2) and patient care (Q9) and overall satisfaction of physicians with COE (Q16). There was also association between information provided by the order entry to write better orders (Q7) and overall, improvement in safety of patient care (Q14) which indicate that the additional information given by COE system allowed physicians to write better order and improved the safety of care they provide. The evaluation further established that the questions were well perceived by the respondents.

There is an increase in the focus of health care institutions towards provision of quality health care comprising of improved patient safety and overall quality of care. Along with formulation of clinical guidelines for management of disease conditions, clinical audits of the prescriptions can serve as a process of improving rational use of medicines and quality of patient care [10].

Prescribing and transcribing of prescriptions plays a significant influence on outcomes of drug therapy and health care of patients [11]. In addition to improved quality of care, COE with CDS also addresses many deficiencies associated with paper based or computerized order entry with no clinical decision support system especially by reducing or eliminating the need to locate patients' charts, the need for order clarification due to illegibility and the need to manually reenter data, which in turn decreases transcription errors and allows immediate transmission of orders. Therefore, the COE with CDS is beneficial in providing better patient safety and quality of care.

CONCLUSION

The impact of COE systems with CDS was especially positive in providing the appropriateness of alerts, decreasing the medication errors, adverse drug events thereby improving the satisfaction and usability. This study suggests that COE system with CDS was efficacious in recognizing drug duplication alert, hepatic alert, lactation alert, maximum dosage alert, drug interactions, therapeutic duplication alert, renal alert, dialysis alert, pregnancy alert, and preconceived physician attitude towards COE with CDS was found to be positive for the improvement in the safety of patient care and for the overall satisfaction with the order entry system. Hence this study recommends that this COE with CDS could be implemented in the hospital settings which could improve the patient safety, support manual audit and save physicians time.

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