ANALYSIS OF COMPLIANCE WITH AUTOMATED DECISION SUPPORT ALERTS FOR CONTRAINDICATED MEDICATIONS USING COMPUTERIZED PHYSICIAN ORDER ENTRY (CPOE)

W.L. GALANTER[1]; R. MRTEK[1]; A. POLIKAITIS[2]
[1]University of Illinois at Chicago, Chicago, Illinois;
[2]Cerner Corporation, Kansas City, Missouri.

Abstract

BACKGROUND: Automated clinical decision support has shown promise in reducing medication errors, however clinicians often do not comply with the recommendations [1,2,3,4]. An understanding of the factors which impact compliance in the computerized provider order entry (CPOE) environment is important as many healthcare systems are planning implementation of CPOE. The benefit of providing alerts in real-time, via on-screen displays during CPOE may be mitigated by non-compliance. We report on factors related to compliance with alert recommendations designed to reduce inpatient use of medications contraindicated due to renal dysfunction in a CPOE environment at an urban academic medical center.

METHODS: Alerts were designed using a commercially available clinical decision support engine[2,3,5]. The warning of contraindication was based on an estimate of the creatinine clearance6 calculated from available patient data. A minimum safe creatinine clearance was established for each medication by the pharmacy. When a contraindicated order was initiated, real-time alerts appeared recommending cancellation of the order as well as providing the patient's creatinine clearance and the minimum safe creatinine clearance for medication use. Inpatient ordering of medications in patients with creatinine clearances less than their minimum safe level was studied for 32 weeks after implementation. The outcome was compliance with alert recommendation. In this preliminary study, the impact of several factors on compliance was examined using bivariate anaylsis with the chi-square statistic and P set at 0.05.

RESULTS: Overall, clinicians complied with 39% of the alerts. Compliance with alert recommendations was found to be associated with the degree of renal dysfunction, with compliance greater when the creatinine clearance was less than half of the minimum safe level as compared to when greater than half the minimum safe level, 57% vs. 36% (P=0.02). Days were split into 2 time periods, 7AM to 7PM (n=148) and 7PM to 7AM (n=64). Alert compliance during the overnight period was greater than during the day, 50% vs. 34%, P=0.05. Housestaff with more than 1 year of training (n=70) were found to be more compliant with the alert recommendations than those with less than 1 year of training (n=91), 49% vs. 33%, P=0.05.

CONCLUSION: Compliance with the alerts was found to be a function of the ordering house officer training as well as the time of day. Compliance was also found to vary with the patient's degree of renal dysfunction. The estimated creatinine clearance of the patient was provided in the alert message, suggesting that clinicians do actually consider the alert recommendation before making a clinical decision. Additional studies are necessary to fully understand how clinical decision support systems can optimally interact with clinicians.

Background

Medical errors are receiving significant attention in the public media as well as in the medical literature.

- The 1999 Institute of Medicine report[7] estimated that potentially up to 98,000 patients die each year due to preventable medical errors. A study on the epidemiology of medical injury from the Harvard Medical Practice[8] indicates that drug complications are the most common adverse event.
- Adverse drug events (ADE's) have been shown to contribute to the mortality and morbidity associated with the treatment of disease, as well as the cost of the care[9].
- A medication error is defined as an error in the dosage or administration of a medication, which has the potential to cause an ADE. Almost all preventable ADE's are caused by medication errors; therefore efforts to reduce medication errors have the ability to impact the rate of ADE's in a substantial manner.

Clinical Decision Support (CDS) systems leverage clinical data gathered in an electronic medical record (EMR) into useful knowledge to assist clinicians in clinical decision-making. Recent studies do demonstrate that computerized physician order entry (CPOE) in conjunction with CDS substantially reduces medication error rates as well as improves the quality and efficiency of medication use.

- Bates[10] demonstrated 55% reductions in serious medical errors through the use of CPOE.
- Raschke[5] demonstrated that a computerized alert system can identify medication errors previously unrecognized by the physician.

Clinician non-compliance has consistently been identified as a limiting factor in the effectiveness of clinical decision support.

- Chertow[1] developed a well-designed CDS system for renal dosing, but efficacy was limited by 50% clinician non-compliance with the expert alert recommendations.
- The effectiveness of the automated CDS developed at the University of Illinois[2,3] for safe inpatient digoxin use was also limited by clinician non-compliance with alert recommendations.
- Oppenheim[4] recently reported that only 52% of medications orders were adjusted in response to CDS alerts warning clinicians of inappropriate dosing due to renal dysfunction.

Methods

Setting: University of Illinois Medical Center (UIMC)

- UIMC is an urban academic 450-bed teaching hospital. Computerized Physician Order Entry (CPOE) has been in use for over 15 years. The majority of medication orders are placed by house officers.

Development of Clinical Decision Support for Renally Cleared Medications

- A decision support committee ("rules committee") consisting of a physician, clinical pharmacists, IT personnel and a Cerner consultant first developed an automated Creatinine Clearance (CrCl) calculator. This calculator posts the renal function estimate to the electronic laboratory clinical flowchart. The intent is to improve clinician recognition of renal dysfunction and thereby promote the safe use of medications. The CrCl calculator is shown to the right in Figure 1.
- The decision support committee then designed and implemented a suite of "rules" to enhance the safe ordering of renally cleared medications at UIMC. The rules utilize the patient's CrCl estimate as well as medication-specific CrCl thresholds established by the clinical pharmacists to evaluate whether the medication being ordered requires dosing adjustment or is completely contraindicated. If deemed necessary the rules generate real-time alerts to the ordering clinician during CPOE. The rule logic is shown below in Figure 2. An example of a real-time contraindication alert is shown to the right in Figure 3.

Analysis of Compliance

- For each contraindication alert the primary outcome of interest was whether the order was completed or cancelled. Cancellation of the order indicated clinician compliance with the alert recommendation.
- To facilitate the aggregation and comparison of alerts generated as a result of various medication orders, the degree of renal insufficiency was calculated for each alert occurrence. The degree of insufficiency was defined as a ratio of the patient's CrCl at the time of the alert occurrence to the minimum safe CrCl for the given medication.
- A variety of factors were examined for their effect on clinician compliance to alert recommendations; practitioner type (MD vs. other), level of house officer training, time of day, as well as the degree of renal insufficiency.

Statistical Analysis

- In this preliminary analysis, bivariate testing was done for each examined factor. The proportions of alert compliance for various groups was compared using Fishers exact test. A P-value of 0.05 was chosen as statistically significant.

Discern Expert®

CERNER DISCERN EXPERT

Discern Expert is an event-driven, rules-based clinical decision support system developed by Cerner Corporation. Discern Expert monitors events of interest and takes action based upon user-defined criteria. Discern Expert* can access all information within Cerner's Millennium* Clinical Data Repository (CDR) – including that generated by a Cerner clinical application or interfaced from a non-Cerner system. A set of defined events trigger or invoke Discern Expert (admissions, transfers, discharges, orders, results, etc.).

Discern Expert provides the ability to act prospectively through synchronous or asynchronous processing. During asynchronous processing, relevant clinical data is analyzed without interaction from the user. In synchronous processing the results of data analysis can initiate a real-time clinical conversation with the user.

Discern Expert users create rules with IF-THEN logic that allows users to apply their own criteria to a set of events and then take actions compatible with their goals.

Discern Expert evaluates or acts at three different levels: Evoke, Logic, and Action.

The *Evoke* section determines what events will "trigger" the execution of a rule (e.g. patient admits, discharges, transfers, information updates, orders, clinical results).

Once the rule has been triggered clinical information captured in the Millennium CDR is evaluated in the Logic section. The evaluated database elements become the "IF" portion of the rule.

The Action section is the "THEN" portion of the rule. The Action section determines what will take place if the rule logic is satisfied. Actions available from a Discern Expert rule include:

- Interactive alert
- Notification – send message to user (email, pager, printed output, clinical Inbox)
- Orders – generate new order, add order, cancel order, and add order comment
- Clinical event - calculate new result, create result, update existing result, add result comment

Figure 1. Creatinine clearance calculation

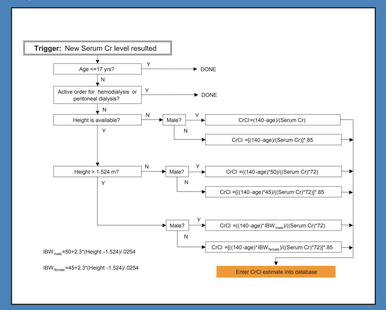


Figure 3. Example of alert

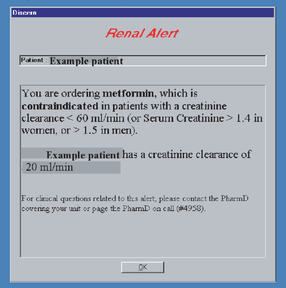
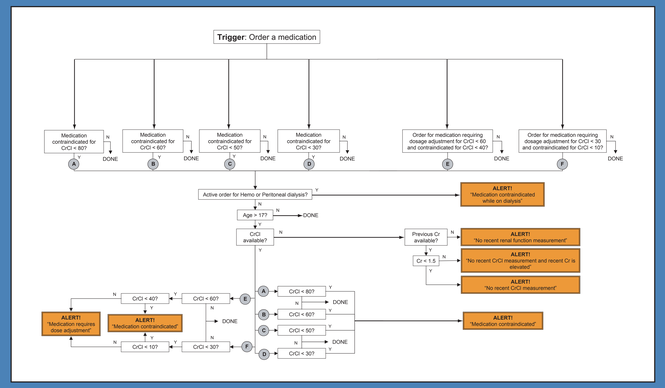


Figure 2. Clinical logic of alerts



Results

- The number of contraindicated medication orders during the study period was 212. The distribution of ordering clinicians is shown below in Figure 4.
- The overall clinician compliance with the alert recommendations was 39%. There was no significant difference in the compliance of the housestaff and non-housestaff clinicians, 40% vs. 37% (P=0.9).
- Compliance to the alert recommendations did not vary with the gender or age of the patient.
- Compliance to the alert recommendations was a function of housestaff training, with more experienced housestaff exhibiting greater compliance as shown in Figure 5 below. Housestaff with less than 1 year of training complied with 33% of the alerts, while those with greater than 1 year of training complied with 49% of the alerts (P=0.05).
- Alert compliance was higher during the overnight hours (7 PM to 7 AM) than during the day (7AM to 7PM), 50% vs. 34% respectively (P=0.05).
- Compliance to alert recommendations was related to the degree of renal insufficiency as shown in Figure 6 below. Alerts generated for patients with CrCl < 50% the minimum safe level for the medication being ordered resulted in higher compliance than alerts generated when the CrCl was > 50% of the minimum safe level, 57% vs. 36% respectively (P=0.04).

Figure 4. Distribution of ordering clinicians

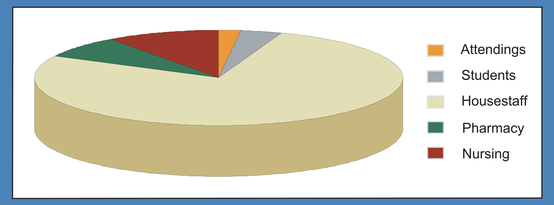


Figure 5. Compliance vs. Training

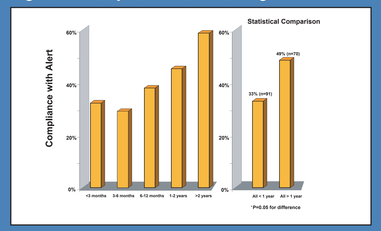
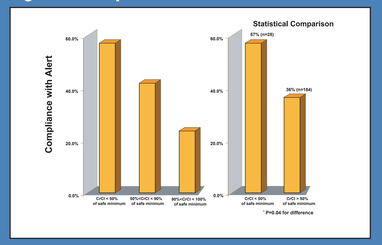


Figure 6. Compliance vs. Renal Function



Discussion

The efficacy of the CDS alerts in this study was limited by clinician non-compliance, similar to many other studies of CDS interventions [1,2,3,4]. It is interesting to note that residents with more training were more likely to be compliant with the alert recommendations. A similar finding was reported by Oppenheim[4]. He hypothesized that inexperienced housestaff may choose to make the appropriate care decisions not immediately at the time of the alert, however with additional consultation, some time after being alerted. This delay in action may make the housestaff only appear to be less compliant. In future analysis of alert compliance we will examine this hypothesis.

The association of alert compliance with the time of day or shift is of interest, especially in light of the new residency work hour restrictions. These restrictions are assumed to improve patient care, based on the idea that more errors occur when residents work longer hours. A priori, it was expected that alert non-compliance would be higher during the overnight hours when residents are fatigued and may be trying to sleep, however instead we found greater compliance at night. There may be several possible explanations for this unexpected result. It is possible that a greater proportion of orders may be placed by experienced residents in the overnight hours. Unfortunately, preliminary analysis does not support this explanation. In addition, during the overnight hours residents are focused on fewer patients, typically admissions to their service only. Residents may not be as distracted with other orders, pages, and responsibilities, allowing them to probably better patient care. Further analysis of the alert compliance data is necessary to better understand this unexpected result.

As additional data is gathered we will perform multivariate analysis to further examine factors that may be important in understanding clinician non-compliance with CDS alert recommendations. The long term goal of CDS systems is to assist clinicians in providing optimal patient care, with only minimal annoyance to clinicians. A better understanding of non-compliance is essential in achieving this future state of CDS interventions.

Conclusions

- Clinician compliance with alert recommendations was greater for housestaff with more than 1 year of training.
- Clinician compliance was greater during the overnight hours, (7PM - 7AM), than during the day (7AM - 7PM).
- Clinician compliance varied with the degree of renal insufficiency. Since the patient´s creatinine clearance was provided in the alert message, this suggests that clinicians do actually read and consider the real-time alert recommendation before making a clinical decision.
- As the overall clinician compliance was less than optimal, future efforts to reduce or overcome clinician non-compliance are necessary to improve the efficacy of automated clinical decision support.

References

1. Chertow GM, Lee J, Kuperman GJ, et al. Guided medication dosing for inpatients with renal insufficiency. JAMA, 2001; 286(22): 2839- 2844.
2. Galanter WL, Didomenico, RJ and Polikaitis A. Preventing exacerbation of an ADE with automated decision support. J Healthc Inf Manag. 2002 Fall;16(4):44-9.
3. Galanter WL, Didomenico RJ, Polikaitis A. Analysis of medication safety alerts for inpatient digoxin use with computerized physician order entry. J Gen Int Med 2002; 17(Supp 1):193.
4. Oppenheim MI, Vidal C, Velasco FT et al. Impact of a computerized alert during physician order entry on medication dosing in patients with renal impairment. Proc AMIA Symp. 2002;:877-81.
5. Raschke RA, Gollihare B, Wunderlich TA, et al. A computer alert system to prevent injury from adverse drug events. JAMA. 1998; 280: 1317- 1320.
6. Cockcroft DW, Gault MH. Prediction of creatinine clearance from serum creatinine. Nephron 16:31-41, 1976.
7. Kohn LT, Corrigan JM, Donaldson MS, eds. To err is human. Building a safer health system. Washington, DC: National Academy Press; 1999
8. Leape LL, Brennan TA, Laird NM et al. The nature of adverse events in hospitalized patients: Results from the Harvard Medical Practice Study II. N Engl J Med. 1991; 324: 337- 384.
11. Bates DW, Spell N, Cullen DJ, et al. The costs of adverse drug events in hospitalized patients. JAMA 1997;277(4):307-311.
12. Bates DW, Leape LL, Cullen DJ, et al. Effect of computerized physician order entry and a team intervention on prevention of serious medication errors. JAMA. 1998; 280: 1311- 1316.

University of Illinois Medical Center at Chicago