Optimising computerised alerts within electronic medication management systems: A synthesis of four years of research

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Abstract. Most studies evaluating the effect of computerised alerts embedded in electronic medication management systems (eMMS) on prescribing behavior demonstrate positive and often substantial effects. But many studies also report that doctors override computerised alerts, sometimes up to 95% of the time. Alert fatigue, due to excessive numbers of alerts being presented, is the primary reason for alerts being overridden. This paper summarises and sythesises a program of research undertaken to determine whether doctors working in a teaching hospital in Sydney, Australia, were experiencing alert fatigue, and to identify and implement strategies for alleviating alert fatigue. We synthesise several published studies adopting a variety of data collection methods (observation of prescribers as they interact with the eMMS, interviews with users, review of alerts generated in eMMS, and a Delphi technique) to present four key lessons learnt. These are: 1) the fewer alerts the better; 2) context of use matters; 3) people use systems in unexpected ways; and 4) user feedback is invaluable.

Keywords. Computerised alerts, decision support, alert fatigue, medication safety, error, electronic health records

Introduction

Computerised alerts embedded in electronic medication management systems (eMMS) have the potential to reduce prescribing errors because they warn prescribers of possible risks such as allergies, inappropriate doses and drug-drug interactions. Most studies evaluating the effect of computerised alerts on prescribing behaviour demonstrate positive and often substantial effects,[1] but many studies also report that doctors override computerised alerts, sometimes up to 95% of the time[2-4]. 'Alert fatigue', due to excessive numbers of alerts being presented, has been identified as the primary reason for alerts being overridden[4]. Alert fatigue represents a significant

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problem for hospitals because it not only results in user frustration and annoyance, but leads to prescribers learning to ignore all alerts, even those that present useful and sometimes safety critical information.

Our recent work evaluating the impact of electronic medication management systems (eMMS) on prescribing errors at two Sydney hospitals revealed that introduction of electronic prescribing resulted in a reduction in the rate of prescribing errors of more than **50%**[5]. This magnitude of reduction in errors has not previously been achieved with any other medication safety intervention. Although this finding is extremely impressive, the reduction observed was primarily due to a large decrease in procedural errors (e.g. fewer incomplete orders) following eMMS implementation. Little change was observed in clinical errors (e.g. wrong doses), those targeted by computerised alerts.

We set out to systemically investigate if computerised alerts were having an impact on prescribing behaviours at one of the study sites and to determine why or why not. In particular, we aimed to determine whether alert fatigue was being experienced by doctors and to identify and implement strategies for reducing alert numbers, thereby improving the effectiveness of alerts as a safety intervention. Here, we synthesise findings from a number of previously published studies [6-9] and present results in terms of four key lessons learnt.

1. Method

1.1. Setting and Details of eMMS

This program of research was conducted at a 320-bed teaching hospital in Sydney, Australia. At the time of the studies, all wards were using the eMMS, MedChart® (CSC: www.isofthealth.com), except for the emergency department (ED). MedChart® is an electronic medication management system that links prescribing, pharmacy review, and drug administration. The system included a range of computerised alerts delivered to prescribers immediately following the selection of a drug (see Table 1).

Table 1. Alert Types in MedChart® [6]

Alert type	Description
Duplication	Displays when a patient is prescribed a medication containing a generic component that is identical to, or belongs to the same therapeutic class as a generic component that has already been prescribed. Alert displays if first order is active on a patient's chart, or if the first order is no longer active, *but was ceased less than 24 hours previously*
Local messages	Displays when a patient is prescribed a medication linked to a local message
	Example alert: "Haloperidol Deconoate (Haldol) is a long acting anti-psychotic used monthly by deep IM injection into the gluteal muscle. Haloperidol (Serenace) is short acting and can be given by deep IM, subcut or IV routes. Please check you have prescribed the correct drug"
Pregnancy	Displays when a medication belonging to an Australian Advisory Committee on Prescription Medicines (ACPM) category other than 'A' is prescribed for a female patient in the age range of 12 to 55 years.
	Note: all ACPM categories but A indicate a possibility of harmful effects to a fetus (http://www.tga.gov.au/hp/medicines-pregnancy.htm).
Allergy	Displays when a patient is prescribed a medication containing a generic component that is identical to, or belongs to the same therapeutic class as a generic component to which the patient has a recorded allergy or intolerance

1.2. Data Collection Methods

1.2.1. Observation

Fourteen specialty teams (46 doctors) were shadowed by an investigator while on ward rounds (58.5h) and twelve junior doctors were shadowed by an investigator after-hours (5pm-10pm, total 65h). All interactions with the MedChart® system were noted, including whether an alert was triggered during the initiation of an order or the editing of an order, the type of alert triggered, whether the alert was read by the doctor, and whether the prescription was changed following the presentation of an alert.

1.2.2. Interviews

Sixteen prescribers participated in a 20-min semi-structured interview. During the interview participants were asked if they read alerts and to comment on the usefulness of alerts, what improvements could be made and what additional decision support was needed.

1.2.3. Chart Review

Electronic medication charts were reviewed daily by a study pharmacist for six weeks (n=180 patient charts). The total number of orders was noted, as was number of orders with at least one alert. For each order with an alert, the following information was collected: prescriber, medication name, date and time ordered, and alert type. For all duplication alerts, the pharmacist also determined if the duplication alert was the result of a prescriber not using a short-cut function in the eMMS. We have labeled these as 'technically preventable' alerts (i.e. the prescriber failed to use the eMMS in the way intended and as a result generated an unnecessary alert)[8].

1.2.4. Delphi Technique

To reach consensus among prescribers on appropriate strategies for reducing alert numbers within MedChart®, 47 prescribers participated in a 2-round Delphi procedure[6]. A 10-question survey was posted in the weekly hospital bulletin in Round 1, and doctors were sent a personalised email containing a link to their Round 2 survey. Doctors were asked about what alert types they found useful/not useful and what alert types they would remove from the eMMS. Feedback about Round 1 responses were incorporated into each question in Round 2 (see Box 1).

Box 1. Sample Round 2 Question

The percentages beside each option below indicate the proportion of doctors who selected that option in round 1.

Q2. If you could remove only one alert type from the current alert set in MedChart®, which type would you remove?

In round 1, you selected 'Pregnancy'.

- Allergy & intolerances (2%)
- Pregnancy (34%)
- Therapeutic duplication (28%)
- Local rule (13%)
- None, I'd not remove any alert type (23%)

2. Results and Discussion

We present and discuss findings from this research in terms of four key lessons learnt.

2.1. The Fewer Alerts the Better

During our chart audit, we found 600/2209 orders (27.2%) had triggered one or more computerised alerts. We identified 934 alerts in total (1.6 alerts/alerted order – see Table 2).

Table 2. Frequency of alert types in a review of 180 patient charts.

Alert type	Number (% of total alerts)
Duplication	572 (61.2)
Local messages	241 (25.8)
Pregnancy	100 (10.7)*
Allergy	21 (2.3)
Total	**934 (100)**

*Twenty patients met the criteria set within the eMMS for pregnancy alert triggers (female, 12-55 years old). Of the 119 medications ordered for these patients, 43.3% triggered a pregnancy alert.

During interviews with prescribers, most participants believed that they received too many alerts and that most alerts were redundant. Some doctors recognised that they had become desensitised to alerts and mentioned that receiving too many was leading to quick dismissal of messages. For example, a registrar said "It pops up so often which can be a very bad thing because you are dismissing it so often that you develop this sort of mechanism, so it can be bad in a sense that sometimes you might miss some important things".

Some modifications to the mechanisms underlying alert generation are clearly needed to ensure that prescribers are presented with fewer but more meaningful computerised alerts.

2.2. Context of Use Matters

During observations on ward rounds, it was immediately apparent that senior doctors made the prescribing decisions. They told junior doctors what medications to order, called medications out to junior doctors who stood at computers in the hallway, and sometimes left junior doctors to enter medication orders into the eMMS while the rest of the team moved onto the next patient case. Senior doctors rarely used the eMMS. Only 17% of alerts were read. No prescriptions were changed following an alert, no junior doctor mentioned an alert to his/her team and no junior doctor questioned a senior doctor's decision to prescribe a medication following an alert. Decision support appeared to not be targeting the decision makers on ward rounds.

In contrast, 78% of alerts were read by junior doctors and 5% of alerts resulted in an order being changed when the eMMS was used after-hours. Decision support was of greater value to less experienced doctors working independently than those working in formal ward round situations. This clinical context presents a specific focus and user group for designers of alerts and eMMS.

2.3. People Use Systems in Unexpected Ways

During observations we noticed that a number of the duplication alerts were being triggered because prescribers were not using all the eMMS functions. For example, instead of using the **'**THEN,**'** **'**AND,**'** or **'**OR**'** functions which allow similar sequential, concurrent, or alternative orders for the same medication to be prescribed together (e.g. frusemide 40 mg in the morning **'**AND**'** 20 mg at midday), users often prescribed the two orders separately, which resulted in the triggering of a therapeutic duplication alert.

During our chart review, we determined that the majority of alerts generated were duplication alerts (n=572, see Table 2) and that one third of these (n=189, 20% of all alerts) were 'technically preventable' (i.e. alert was the result of a prescriber not using a short-cut function in the eMMS). Prescribers did not use the eMMS functions as intended, despite the functions' potential to improve efficiency of work.

Frequent sub-optimal use of system functions suggests that either the efficient strategies are not known to users, that the strategies are known but system design features are poor, or the system functions are not viewed by users as beneficial or consistent with preferred prescribing practice, resulting in strategies not being used. We suggest that several functions in the eMMS designed to improve efficiency require clinicians to think about their prescribing tasks in different ways than when prescribing on paper.

2.4. User Feedback is Invaluable

During interviews, doctors made some suggestions about how to improve the effectiveness of the computerised alerts including shortening the alert text, making different alert types more distinguishable from one another, and indicating the level of risk associated with each warning. Inappropriate alert content and design have been identified as factors that limit the usefulness of computerised alerts[10,11], but speaking to users allowed us to detect specific problem areas and discuss some constructive solutions. A resident said "I guess less words and more point forms would be easier because then we wouldn't have to scroll through paragraphs and sentences of text".

Our Delphi study also allowed us to identify several strategies that users viewed as appropriate for reducing the rate of alerts. Nearly all prescribers (95%) agreed that local messages could be removed from the eMMS and presented as 'hyperlinks' on the prescribing screen. In the same way most prescribers (91%) thought that changing duplication alerts so that they only fired when the initial order was active on a patient's chart (rather than the order being ceased within 24 hours, see Table 1) would be safe. Implementation of these strategies would eliminate more than half of the alerts being triggered in the system.

Prescribers varied in their views on what alert types should be removed but 76.2% indicated that pregnancy alerts were 'never' or 'rarely' useful. Prescribers agreed on what alert type should be retained: 81% of participants rated allergy alerts as most useful and no participant believed that this type should be removed.

3. Conclusions

Over the course of our four-year program of research we learnt that getting alerts right within eMMS is an extremely challenging task. The best approach appears to be to include only a small number of alerts and then to provide alternative forms of decision support to prescribers (e.g. pre-written orders). This ensures that prescribers are not over-alerted and minimises the probability of alert fatigue. For example, this hospital chose not to implement drug-drug interaction alerts within its initial alert-set as they were mindful of over-alerting prescribers. Based on this research, all pregnancy alerts were removed from MedChart® and many of the local messages were replaced with corresponding pre-written orders. We are currently in the process of assessing the clinical impact of altering therapeutic duplication warnings so that they only fire when the initial order is active on a patient's chart.

Continuous evaluation of alerts using both quantitative and qualitative approaches is vital to ensure that alerts remain relevant and effective. Observing users in naturalistic settings can reveal some unexpected results (i.e. limited impact of decision support on decision-making, suboptimal use of eMMS functions). Following the discovery that too many alerts are being presented, the Delphi method represents a useful approach to identify strategies for alert removal. Most importantly, seeking input and feedback from users, and involving users in system (re)design is crucial and we expect greater ownership and acceptance of alerts by prescribers to follow.

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