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Impact of Alert Specifications on Clinicians' Adherence

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Abstract. Computerized alerts provided by health care information systems have been shown to enhance clinical practice. However, clinicians still override more than half of the alerts. This indicates that certain aspects of alerts need improvement to fulfill their purpose of supporting clinicians in decision making. This paper reports on a systematic review on studies evaluating alert specifications and their impact on clinicians' alert adherence. The review revealed that use of colors and icons to distinguish different alert severity levels and presenting high severity alerts in an interruptive fashion increases clinicians adherence to alert recommendations. Alert message contents that lack clinical importance or provide incorrect texts increase alert non-adherence. Few studies have yet focused on the impact of alert specifications on clinicians' adherence. A research agenda is needed on alert specifications and their impact on clinicians' adherence in order to develop alerts that truly support clinician decision making.

Keywords. Hospital Information Systems, Alert, Reminder Systems, Clinicians Adherence, Design aspects, Clinical Decision Support

1. Introduction

Clinical decision support systems (CDSS) can have beneficial effects on clinicians' performance in daily practice (1). Certain types of CDSS provide decision support through computerized alerting of clinicians on (critical) situations that require their attention or special action. Alerts provided by Computerized Physician Order Entry (CPOE) systems have been proven to reduce duplicate orders, overdoses, allergic reactions, and drug interactions (2). Also, higher clinicians' compliance to clinical guidelines has been reported as a beneficial effect of alert implementation (3). However, one of the barriers to attaining these beneficial effects is that 49% to 96% of the alerts are still overridden (4), undermining their purpose. Often heard reasons for overriding an alert is "alert-fatigue" as a result of low specificity (4, 5). Alerts of low specificity are often 'clicked away' without being read even when overriding them could cause adverse events. Next to alert specificity, the graphical alert design influences alert overriding; a minor change in the design of an alert shown on a computer screen may have a major impact on a clinician's action (6). However, in what way alert specifications of different severity and specificity may affect clinician adherence is still unclear. In this paper we present the findings of a systematic review of studies that evaluated effects of interventions concerning different alert specifications on clinicians' adherence.

2. Methods

In this systematic review we define an 'alert' as 'a message that becomes visible to inform the user of a certain situation that requires attention'. An alert is generated by a rule base that is incorporated in a health care information system. In this review we refer to health care information system as defined by (7): "all computer-based components which are used to enter, store, process, communicate, and present health related or patient related information and which are used by health care professionals or the patient themselves in the context of inpatient or outpatient patient care". Alert characteristics which are defined in this review are 'type', 'design' and 'message content'. *Type* is defined by two characteristics; intrusive/non-intrusive and interruptive/non-interruptive. Intrusive messaging is considered if it overlays the computer ordering screen. Alert messaging is defined as interruptive if they require a user action before a clinician can proceed with the next step of ordering (e.g. providing a reason for alert overriding). *Design of an alert* is defined by two elements: graphical (e.g. the use of colors), and screen (e.g. the size of an alert or its components, the alignment of alert components, and the use of icons). *Message content* of an alert is defined as informative content of the alert that is shown to the user (e.g. alert severity, options for alternative treatments etc.). *Clinician's alert adherence* is considered in terms of a clinician following the recommendation of the alerts message.

MEDLINE and EMBASE were systematically searched from January 1, 1990 until January, 1 2009 using a combination of Medical Subject Headings (MeSH terms) and keywords. These terms were grouped as (A) interactive computer systems, (B) alert, warning, reminder, or feedback, (C) alert specifications (e.g. design). Within each group, the terms were combined by the operator "OR". The three groups were combined by the operator "AND". The search was narrowed down to articles written in English. All titles and abstracts of these articles were reviewed by the first author. The two other authors each reviewed half of the total set. Studies were rated as relevant if in the abstract the following items were mentioned: 1) the system under study is an interactive health information system, 2) the study is about clinician alert adherence, and 3) the study objective is the evaluation of at least one of the following alert specifications (type, design, or message content). Selected articles were discussed in a meeting and if all three reviewers agreed upon inclusion, full texts were reviewed. A standard data collection form was applied to review the included articles.

3. Results

The literature search generated a total of 1711 articles (MEDLINE 1055, EMBASE 656) of which 386 were duplicates. From the remaining 1325 articles, 16 were selected for full text review based on their titles and abstracts. After full text review, only seven articles were found eligible for inclusion. One was excluded because it was about a system that had no interactive user interface, four were excluded because the full text did not provide detailed information on the alert specifications, and four were excluded because they did not accurately describe the study designs. Table 1 gives an overview of the included articles with the year of publication, study design, setting, system type, the results in terms of alert specifications, and the described effect on clinicians' adherence. Full references of the included studies are provided in a technical report, which can be found at (8).

Table 1. Overview of studies evaluating impact of alert specifications on clinicians' adherence

Investigator, Year of Pub.	Study design	Settting	System	Alert specification	Effect
Shah NR *et al.,* 2006	Descriptive	Outpatient	CPOE	***Type:*** Tiered based on severity level; 1) interruptive requiring elimination of interaction 2) interruptive requiring reason 3) not interruptive	Positive
Paterno MD *et al.,* 2009	Cohort study	Inpatient	CPOE	***Type:*** Tiered based on severity level; 1) interruptive requiring discontinuing one of the orders 2) interruptive requiring discontinuing one of the orders or providing a reason 3) not interruptive	Positive
van Wyk JT *et al.,* 2008	RCT	Outpatient	EHR	***Type:*** Automated alerting vs. on-demand alerting	Positive
Alexander GL 2007	Descriptive	Inpatient	EHR	***Type:*** Automated alerting vs. on-demand alerting	No effect
Eliasson M *et al.,* 2006	Cross-sectional	Outpatient	CPOE	***Design:*** Colors to indicate severity: red = high, yellow = medium, white = low ***Design:*** Different icons for domain of notification (Pregnancy, Breast-feeding, Medication).	Unclear
Taylor L *et al*., 2004	Descriptive	Outpatient	CPOE	***Content:*** clinical importance of alert, and correctness of drug/disease information	Negative
Tamblyn R *et al.*, 2008	RCT	Outpatient	CPOE	***Type:*** Automated alerting vs. on-demand alerting ***Content:*** clinical importance of alert, and correctness of drug/disease information	No effect on type, Negative effect on content

Five of the studies provided specific information about the different types of alerts. Shah et al. tiered the presentation of a selective set of alerts based on their severity levels into 3 categories. Categories one and two were considered severe and were designed to interrupt the clinician requiring a direct action; either eliminating the contraindication for level 1 or providing an override reason for level 2, while, the less severe ones, level 3, were presented in a non-interruptive fashion, requiring no action by clinicians. This study reported an adherence rate of 67% with interruptive alerts requiring action. Paterno et al. studied whether the rate of clinician compliance with drug-drug interaction alerts improved when a tiered presentation of alerts was implemented. Alert log data were analyzed at two academic medical centers using the same alerts but one displayed alerts by severity level (tiered presentation) while the other did not. This study showed that the overall compliance rate for tiered alerts was almost three times higher than for non-tiered alerts (29% vs. 10%).

A randomized control trial (RCT) by Van Wyk et al. studied automated alerts (the recommendation is automatically shown to the user) and on-demand alerts (a user has to actively initiate the overview screen to access the recommendation) versus no

intervention. The RCT showed that the alerting version significantly improved the performance of clinicians for screening and treatment of dyslipidemia as compared to the on-demand version. Another RCT study by Tamblyn et al. compared the effect of customizable automated alerts and customizable on-demand alerts on drug prescribing problems and alert overrides. A greater absolute number of automated alerts were seen and revised by clinicians, but both groups underused the alerts. As a result, there was no significant difference in the overall prevalence of prescribing problems by the end of the follow-up period. Therefore clinician adherence was not affected. Likewise, the study of Alexander investigated the impact of automated alerts compared to on-demand alerts on clinical responses of health care providers and reported no significant difference in clinicians' adherence.

Only one of the studies, Eliasson et al., provided specific information about the visual design aspects of alerts. This study investigated a system where icons (differing in type for pregnancy, breast-feeding, and medication) appeared in patient situations that required attention. The background color of the alert changed for the various severity levels; Red for high, Yellow for medium, White for low. This study showed that these types of alerts were quickly adopted in daily clinical routine. The adoption can be due to adherence to alerts, though the study did not directly mention the actual effect of the alert design specifications on clinicians' adherence.

Two of the studies, Taylor et al. and Tamblyn et al, reported on content specificities of alerts. Taylor assessed the feasibility and performance of automated alerts within an electronic decision support tool of a prescribing system. Among other reasons, lack of clinical importance of alerts and incorrectness of drug/disease information respectively counted for 34% and 4% of clinicians' non-adherence to automated alerts. Tamblyn et al. likewise showed that from the total number of alerts seen by clinicians 16% were ignored because of incorrectness of drug/disease information and 29% because of lack of clinical importance.

4. Discussion

The findings of this systematic review suggest that specific types of alert presentation can influence clinicians' adherence to the recommendations provided. First, clinicians' acceptance of alerts and likelihood of compliance with the alert recommendations could increase when they would only be interrupted by alerts of highest severity, which is with the highest clinical importance. A reduction in the number of interrupting alerts, particularly those with low severity, could prevent alert fatigue and alert overriding by clinicians. Automated alerts rather than on-demand ones do not seem to be associated with better performance of clinicians though in the RCT by Van Wyk et al. automated alerts improved adherence in comparison to on-demand alerts. The results of this RCT are consistent with the findings of a major review (8). This review showed that clinicians' performance is improved in conditions wherein they are automatically prompted by clinical decision support systems compared to situations which required them to activate the system themselves. These conflicting results may be explained by the fact that other factors besides alert specifications such as alert specificity and severity which likewise influence clinicians' adherence were neglected.

Certain alert design specifications have a positive influence on clinicians' adoption of alerts. One of the studies in this review showed that the use of different colors for differentiating alert severity levels and the use of icons for indicating the domain of

notification may enhance clinicians' awareness of situations requiring their attention and improve quick adoption of alerts in clinical practice. The effect of these alert designs on clinicians' alert adherence yet remained unclear.

The message content specification of an alert might also impact clinician adherence. Two studies showed that that alerts with incorrect information and unclear clinical consequences were among contributing factors of clinician non-adherence, which findings were acknowledged by Van der Sijs (4). This systematic review has several limitations. Because the term "alert" is not a MeSh term, the term "alert" was combined with other but similar terms like "warning" and MeSh terms like "feedback" and "reminder" to find relevant articles. Further work is to broaden the search strategy to find more studies that might shed light on other alert specifications and their impact on clinicians' adherence to the alerts. Furthermore, only two of the seven studies concerned RCTs which produced conflicting results, so the results are poor and inconclusive. Besides the limited number of studies and RCTs found by this review, most of the included publications focused on the effect of one single alert specification on clinicians' adherence. Therefore, the reported adherence might be influenced by other alert specification aspects not of focus in the study, biasing the study results. Most important, adherence is influenced by alert specificity and severity as well. A research agenda is needed to investigate the impact of variations in alert specifications in relation to alert specificity and sensitivity on clinicians' adherence. The ultimate aim is to develop alert designs that truly support clinician decision making and improve clinical outcomes. We will start this research by experiments evaluating the effect of different types, designs and message contents of alerts in relation to alert specificity and sensitivity level on clinicians' adherence in two Dutch academic hospital settings.

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