Discussion of "Attitude of Physicians Towards Automatic Alerting in Computerized Physician Order Entry Systems"

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With these comments on the paper "Attitude of Physicians Towards Automatic Alerting in Computerized Physician Order Entry Systems", written by Martin Jung and co-authors, with Dr. Elske Ammenwerth as senior author [1], the journal wants to stimulate a broad discussion on computerized physician order entry systems. An international group of experts have been invited by the editor of Methods to comment on this paper. Each of the invited commentaries forms one section of this paper.

12. Comment by M. Peleg

The paper by Jung and coauthors reports on an international survey conducted to assess the attitudes of physicians towards automatic alerting in Computerized Physician Order Entry (CPOE) systems. What are the attitudes of physicians towards CPOE alerting? Do the attitudes vary between different countries, organizational and technical settings? Are the attitudes of physicians who are already using CPOE systems different than those of physicians who are not currently using CPOE systems? The results are encouraging and in agreement with previous studies that assessed attitudes towards alerting in CPOE systems for single healthcare institutions: physicians see the great benefit that alerts provide for identifying potential errors in prescribing medications. They do not think that reacting to alerts costs them too much time. Although certainly a single hospital is not representative of all hospitals in a country, it is striking to see that the pattern of answering 15 different questions that assessed different aspects of physicians' attitudes towards CPOE alerting is very similar in all 11 hospitals, regardless of the difference in country, in setting, and in experience of using CPOE.

Alerting takes account of a vast amount of detailed facts, such as contra-indications and drug interactions, which need to be considered during prescribing and calculations of dosage; these fit precisely with tasks that computers are better at than human beings. In different hospitals world-wide, CPOE alerting have capabilities such as support of dosage calculation, consideration of drug-drug interactions, duplicate therapies, drug allergies, drugs preferred by the hospital's health plan, drug-disease contra-indications, and some can provide guidance for medication-related laboratory testing. The positive attitudes are present despite the fact that physicians recognize possible alert overload as a major problem. Hence, it seems that they are willing to accept alert overload realizing the importance of patient safety. The positive attitudes are also indicative of the success of CPOE systems. Much work has been done to address barriers to successful use of CPOE systems, in particular specificity of alerts to patients data and to healthcare professional's specialty, addressing workflow issues and timing of alerts, their relevance, and seriousness (i.e., whether ignoring an alert could be fatal), as well as limiting the amount of work that needs to be done to work with the CPOE system when accepting or overriding an alert [41].

Opportunities for biomedical and health informatics research related to CPOE alerting

So, given these positive attitudes, is work for researchers in this field done? Although I am not an expert on CPOE systems, I see opportunity for research in several directions.

The first direction includes evaluation studies that evaluate together effectiveness of CPOE reminders on reduction of prescribing errors with physician attitudes. Such studies could try to compare the impact of cultural differences between countries, organizational setting (e.g., hospital or medical group), technical setting, and physicians' personal experience with CPOE systems, as done in this study. Furthermore, the studies can address specific capabilities of the CPOE alerting system, such as drug-diseases contra-indications, in conjunction with differences in organizational, technical, or cultural settings. CPOE alerting systems have added benefits when the patient's problem list is complete, which may be true in the setting of primary-care clinics but not at the setting of a general hospital. In the survey described in the paper, only one hospital supported drug-disease contra-indication checking. The fact that this functionality was not available in the other seven hospitals with CPOE systems assessed, might be because the hospital managers realized that contra-indication alerts will not be generated when medical records do not contain enough information about patients' medical problems and allergies, or when this information is not structured but is documented in free text, which is hard to process. Moreover, if physicians receive some alerts for contraindications they may incorrectly assume that when the system does not generate a contra-indication alert this means that their other prescriptions are free of contra-indication errors. Hence, their interpretation of the system's lack of alert (error of omission) may cause a false-negative error, prescribing a drug (error of commission) that is contra-indicated while not realizing the problem of incomplete medical records. Problems may also occur with medical records that are not kept up-to-date. Such records may indicate that the patient is taking medications that he stopped taking. In this case, the system may generate false-positive alerts. Additionally, if the system contains outdated record of the patient's weight, errors (of commission) in drug dosage recommendations may result. Errors of CPOE alerts (false negatives or false positives) could result in physicians not trusting the system and ignoring its recommendations.

The second direction of research lies in learning from non-clinical domains in which alerting is successfully used. One such domain is IT security, for example, the generation of alerts of potential security breach by Internet browsers or anti-virus software. Browsers contain default security settings that can be set up by the user's organization to different levels of security. Setup options include optional warnings when a site tries to install add-ons. Reported attack sites and web forgeries could be blocked and specific web sites could be added to a list of sites allowed to install add-ons. A user can override the organizational security setting and change the level of security, for example, when he receives an alert about a particular site trying to install an add-on, he can allow this site single access or access for a limited duration of time. If too many alerts are generated for a site that he trusts, he may add this site to the list of allowed sites, and decide to turn off the alerting system. Of course, such risky behavior prevents the system from functioning correctly and is especially problematic when patient safety is concerned.

An interesting line of research is in the study of physician user behavior. Such research in the non-healthcare setting, tries to understand users' security-related behavior and to predict how system features will affect user actions. This line of research has theoretic contributions from fields such as psychology, human-factors engineering, economics and decision making. Based on a conceptual model that draws from all of these disciplines, Ben-Asher and coauthors [83] developed a controlled research environment to study users' tendency to take precautionary actions as a function of the tradeoff between a system's usability and the level of security the system provides. The environment consists of a modified version of a "Tetris" game and includes an alert system that warns about possible virus attacks, which, if not prevented, can cause losses of monetary earnings. Users could alter the threshold settings of the security system. The system allows us to manipulate the usability cost of using a security feature, the severity of the consequences of an attack, the likelihood that a threat will occur, and the statistical properties of the security system. Preliminary results demonstrated that when attacks were more likely, participants selected more cautious thresholds, and tended to respond more to security system alerts. It is interesting to apply such research methods to the medical domain and to study how the likelihood of certain types of medication errors affects user attitudes towards CPOE alerting.

From the paper by Jung et al., we learn that different healthcare organizations use different options for controlling the tradeoff between usability and safety in CPOE alerting. These include the following properties of alerts: automatic, optional, and interruptive. These options allow the organization to impose safe behavior by physicians during order entry. However, organizations are aware of incompleteness of the alerting rules and of the fact that physicians can get annoyed from systems that produce too many false positive alerts. Therefore, as is done in IT security where users can allow exceptions for some sites to install add-ons, some CPOE systems allow entering exceptions or mitigating circumstances that make it easy to influence the number and accuracy of future alerts [41]. To prevent annoying repetition, users that perform well can be allowed to turn off alerting for certain periods of time. At the same time, alternative actions are presented and reasons for non-compliance are requested. Research could address the design of pre-enumerated justification options or automatic processing of natural language justification. It would also be interesting to use probabilistic approaches to infer from users' requests to override system alerts, which alerts are problematic and should be changed.

It is interesting to note that the three hospitals with the highest scores used more sophisticated alerting strategies which only interrupt users for the more important and severe warnings while the three hospitals with the lowest scores only offer automatic and interruptive alerts. These findings support the need for research on sophisticated alerting strategies that make alerts more sophisticated and specific, in order to decrease the number of false-positive alerts and increase their relevance while maintaining patient safety. An example for this kind of research is shown in the paper by Riedmann and other colleagues from the University for Health Sciences, Medical Informatics and Technology, Hall in Tirol, Austria, who also led the study reported in this paper (Jung, Hackl, Ammenwerth) [74]. The authors have used a combination of literature searches and expert interviews to identify and validate the possible context factors of an alert. Their context model contains twenty factors, which they grouped into three categories: characteristics of the patient or case (e.g., clinical status of the patient); characteristics of the organizational unit or user (e.g., professional experience of the user); and alert characteristics (e.g., severity of the effect).

Another line of research would be to use machine-learning methods to learn which alerts should be modified and in which ways. Such learning could use information regarding compliance or non-compliance to alerts, alternative actions used, and justifications for deviation provided. In addition, learning should also use contextual information about the alert and patient outcomes to learn about effective deviations from alert recommendations that for particular alert context led to better outcomes. This approach is similar to that used by Soffer, Ghattas, and Peleg [84] for learning how to improve business processes and healthcare processes based on context and outcome.

Using knowledge-based decision-support with CPOE system to generate context-specific recommendations while employing sophisticated strategies could also benefit from the rich literature on computer-interpretable clinical guidelines [85,86,87]. Works in this field address challenges such as sharing of executable clinical knowledge by different implementation sites, ontological approaches for semantic integration of formalized medical knowledge with electronic health records [88] and hospital information systems, models for decision-making, including argumentation-based logic [89] and probabilistic decision-theoretic models, and temporal abstraction and reasoning [90].

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