Overrides of medication-related clinical decision support alerts in outpatients

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ABSTRACT

Background Electronic prescribing is increasingly used, in part because of government incentives for its use. Many of its benefits come from clinical decision support (CDS), but often too many alerts are displayed, resulting in alert fatigue.

Objective To characterize the override rates for medication-related CDS alerts in the outpatient setting, the reasons cited for overrides at the time of prescribing, and the appropriateness of overrides.

Methods We measured CDS alert override rates and the coded reasons for overrides cited by providers at the time of prescribing. Our primary outcome was the rate of CDS alert overrides; our secondary outcomes were the rate of overrides by alert type, reasons cited for overrides at the time of prescribing, and override appropriateness for a subset of 600 alert overrides. Through detailed chart reviews of alert override cases, and selective literature review, we developed appropriateness criteria for each alert type, which were modified iteratively as necessary until consensus was reached on all criteria.

Results We reviewed 157,483 CDS alerts (7.9% alert rate) on 2,004,069 medication orders during the study period. 82,889 (52.6%) of alerts were overridden. The most common alerts were duplicate drug (33.1%), patient allergy (16.8%), and drug–drug interactions (15.8%). The most likely alerts to be overridden were formulary substitutions (85.0%), age-based recommendations (79.0%), renal recommendations (78.0%), and patient allergies (77.4%). An average of 53% of overrides were classified as appropriate, and rates of appropriateness varied by alert type (p<0.0001) from 12% for renal recommendations to 92% for patient allergies.

Discussion About half of CDS alerts were overridden by providers and about half of the overrides were classified as appropriate, but the likelihood of overriding an alert varied widely by alert type. Refinement of these alerts has the potential to improve the relevance of alerts and reduce alert fatigue.

INTRODUCTION

Clinical decision support (CDS) represents an important tool for promoting patient safety and quality of care, and medication-related CDS is especially useful. Physicians can choose to accept or override nearly all CDS alerts, and understanding how physicians respond to these alerts is critical to obtaining benefit from them.

Simply having an electronic health record appears to have little impact on quality by itself. However, a variety of randomized controlled trials clearly demonstrate that CDS can improve care. To improve both quality and safety, key system functionality must be both implemented and used, though prior work suggests that uptake of such functionality has been highly variable among adopters of electronic health records.

Therefore, since the start of 2011, providers have had the opportunity to be rewarded by the government for achieving core objectives of meaningful use of certified systems in Stage 1 of this program, and Stage 2 will raise the bar further. Relatively few data are available regarding the impact of meaningful use of medication-related CDS, though this does appear to be one of the first areas in which conversion to an electronic medical record may improve care, especially safety.

Overall, use of electronic prescribing has the potential to improve safety, efficiency, and quality, though a variety of work suggests that this does not occur in all instances. For example, data from our center show that there is substantial room for improvement in the meaningful use of electronic medication lists, a basic component of electronic prescribing. We studied more than 4,000 clinicians and found that only 66% appeared to be meaningfully using medication lists. Furthermore, although we have extensively modified the CDS system at our center to promote user acceptance and reduce alert fatigue, we have continued to observe a high level of CDS alert overrides. With the implementation of electronic health records and CDS, we now have an additional resource: logs capturing individual providers’ responses to CDS relating to medication safety and efficiency. While these have been available in many electronic health records, others do not track them, and we believe they have been underutilized.

A better understanding of what alerts are delivered, whether providers override them, and what responses providers offer when they respond to them may provide insights into how the alerts themselves should be delivered, and also into policies around meaningful use. Therefore, we performed a study with the following three aims: (1) to characterize the types and numbers of alerts delivered in the ambulatory setting; (2) to characterize the frequency with which they are overridden; and (3) to describe providers’ reasons for overriding them and the appropriateness of those reasons.

MATERIALS AND METHODS

Study setting and design

We obtained CDS alert override rates and the system-coded reasons for overrides selected by providers at the time of prescribing from outpatient clinics and ambulatory hospital-based practices at a
Drug, drug-class interaction, and class-class interaction domains. This provided a total sample size of 600 overrides for analysis of alert appropriateness. Each group member analyzed 1–2 of these samples to assess whether the overrides were appropriate.

### Outcomes

Our primary outcome was the rate of CDS alert overrides. Our secondary outcomes were the rate of overrides by alert type, the reasons cited for overrides at the time of prescribing, and the appropriateness of the overrides.

### Analysis

We compared CDS alert override rates and the appropriateness of overrides among the different alert types in our sample. Comparisons are presented as counts with percentages, and p values were calculated using the $\chi^2$ test.

### RESULTS

A total of 1718 providers received 157,483 CDS alerts (7.9% alert rate) on 2,004,069 medication orders during the three-year study period. Provider types included staff physicians (N=8,855, 49.8%), house staff (N=616, 35.9%), nurse practitioners (N=79, 4.6%), and physicians’ assistants (N=35, 2.0%). A total of 133 providers (7.7%) did not have a provider type listed. Providers override 82,889 (52.6%) of the alerts generated. Table 1 shows alert and override rates as well as the most common reasons cited for overrides at the time of prescribing in each of the eight alert types. The most common alert types were duplicate drug (33.1%), patient allergy (16.8%), and drug–drug interaction (15.8%). Table 2 shows the annual alert override rates over the three-year study period. The alert rates and the alert override rates decreased in year 2 (p<0.001) and increased in year 3 (p<0.001). Although these differences were
highly statistically significant because of the large sample size, the differences were small.

We found significant variation in override rates by alert type (p<0.001), with rates varying widely from 24.4% to 85.0%. The most likely alerts to be overridden were formulary substitutions (85.0%), age-based recommendations (79.0%), renal recommendations (78.0%), and patient allergies (77.4%). In our subset of alert overrides analyzed for appropriateness, we found that the appropriateness of alert overrides also varied significantly by alert type (p<0.001), from 12% for renal recommendation alerts, to 92% for medication allergy alerts. Interestingly, overrides of drug–class and class–class interactions were more appropriate (88% and 69% appropriate, respectively) than overrides of individual drug–drug interactions (12% appropriate). Table 3 shows the rates of appropriateness for alert overrides by alert type, and table 4 shows examples of appropriate and inappropriate overrides by alert type. Our inter-rater reliability for assessment of alert appropriateness was very good (κ=0.89).

Providers cited a variety of reasons for overriding the CDS alerts, with the most common overall being that the patient had previously tolerated the drug. The reasons cited for alert overrides varied by alert type. For example, the most common reason cited for overriding drug–drug interaction alerts was that the provider ‘will monitor as recommended’ (42%). The most common reason cited for overriding formulary substitutions was ‘failure or intolerance to suggested substitution’ (44%). Table 5 shows override reasons by alert type.

**DISCUSSION**

In this study, we found that about half of CDS alerts were overridden by providers, and the rate of overrides varied substantially by alert type. Both the alert and override rates decreased in year 2 and increased modestly in year 3. Half of the overrides were appropriate, and the proportion that was appropriate varied even more by alert type. Few overrides of renal dosage recommendations, drug–drug interactions, or age-related dosage recommendations were appropriate, while the vast majority of drug allergy, drug–class, duplicate drug, and drug formulary alerts were, suggesting that this last group might be particularly good targets for refinement to reduce alert fatigue by reducing the number of alerts. Notably, the appropriateness of overrides of drug–class and class–class alerts was much higher than that of individual drug–drug alerts. This could indicate that while providers generally agree with alerts based on larger categories of drugs and their potential interactions, they may feel that exceptions do exist for individual drugs. However, the high rates of inappropriate overrides for these individual drug–drug interactions indicate the need for further education and intervention.

Our results are consistent with existing literature, which reports override rates ranging from 50% to more than 90%, with drug–drug interactions being one of the most common alert types to be overridden, although few previous studies have compared such a broad array of alert types, and we believe these results may help organizations consider which ones to focus on.13–18 While the overall override rate in this study is at the lower end of what is reported in the literature, it is higher than the rate we reported from our ambulatory care practices in a prior study in 2006.14 At that time, we found that 33% of interruptive CDS alerts in outpatient systems were overridden, with override rates ranging widely by the type of warning, from 23% for duplicate class warnings to 90% for drug–pregnancy interactions.14 Our current higher overall rate of overrides suggests that the number of alerts that our clinicians experience has probably grown, which could lead to alert fatigue.19–21 There are two possible reasons for this increased number of alerts. First, we may have a lower threshold for alerting. The natural tendency is for committees that manage alerts to add alerts

<table>
<thead>
<tr>
<th>Alert type</th>
<th>Example of inappropriate override</th>
<th>Example of appropriate override</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient allergy</td>
<td>Antibiotic prescribed to a patient with a listed allergy to that antibiotic</td>
<td>Narcotic prescribed to a patient with a listed allergy to a different narcotic</td>
</tr>
<tr>
<td>Drug–drug interaction</td>
<td>Warfarin prescribed in conjunction with a fluoroquinolone and no monitoring of INR</td>
<td>Warfarin prescribed in conjunction with a fluoroquinolone and close monitoring of INR</td>
</tr>
<tr>
<td>Duplicate drug</td>
<td>Duplicate prescription for an antihypertensive after a dose increase, when the lower dose was not discontinued</td>
<td>Steroid taper prescribed with different doses of the same steroid</td>
</tr>
<tr>
<td>Drug–class interaction</td>
<td>ACE inhibitor prescribed to a patient already on a different ACE inhibitor</td>
<td>ACE inhibitor prescribed to a patient already on a different ACE inhibitor only while transitioning from one drug to the other</td>
</tr>
<tr>
<td>Class–class interaction</td>
<td>Hypnotic and benzodiazepine prescribed simultaneously</td>
<td>Hypnotic and benzodiazepine prescribed simultaneously only while transitioning from one drug to the other</td>
</tr>
<tr>
<td>Age-based suggestion</td>
<td>Long-acting benzodiazepine prescribed as first-line therapy in a benzodiazepine-naïve elderly patient</td>
<td>Short-acting benzodiazepine prescribed at minimum dose as second-line therapy in elderly patient who has tolerated benzodiazepines in the past</td>
</tr>
<tr>
<td>Renal suggestion</td>
<td>Metformin prescribed to a patient with creatinine clearance &lt;50</td>
<td>Metformin prescribed to a patient with creatinine clearance &gt;50</td>
</tr>
<tr>
<td>Formulary substitution</td>
<td>Prescriber selected proton pump inhibitor that patient has taken in the past instead of choosing formulary substitution</td>
<td>Prescriber selected selective serotonin reuptake inhibitor that patient has been taking long-term instead of choosing formulary substitution</td>
</tr>
</tbody>
</table>
Our study provides some important additions to the existing literature. First, we assessed the override responses to a very broad range of medication alert types, such as age-based and renal recommendation, which most prior alert studies have not assessed. Second, we evaluated the appropriateness of alert overrides, and found that appropriateness varies dramatically by alert type. Few studies have evaluated the appropriateness of alert overrides,\textsuperscript{24} and little prior data exist about the appropriateness of overrides by alert type. Appropriateness can be hard to evaluate, but our inter-rater reliability for assessment was good (κ=0.89). Of course, providers may have had information that the reviewers did not, but this was likely the case in only a small minority of cases as reviewers had access to the complete electronic medical record. Further research into the appropriateness of alert overrides may help identify a number of ways in which alerts can be improved. For example, in many instances alerts might be made more specific, with one example being suppressing alerts if a patient has been taking a combination of interacting drugs for some time, or bringing in additional factors such as the presence of laboratory tests or symptoms. Additional research may also enable characterization of the variation in appropriateness of alert overrides at the physician level in order to formulate targeted interventions aimed at prescribers who have high inappropriate override rates.

Our study has several limitations. First, our results represent data from ambulatory care practices affiliated with a large, academic healthcare center. We did not study inpatient practices. Second, the alerts that were identified originated from a single internally developed CDS system. Our sample did not include other internally developed and/or commercially available CDS systems. Third, as mentioned in the methods section, our analysis on the appropriateness of alert overrides was based on a randomly-selected subset of overrides. In addition, we did not specifically assess whether patients were harmed as a result of alert overrides. We also did not specifically examine clustering of CDS overrides or their appropriateness by provider. Due to their cost and complexity, analyses of patient harm are typically focused on a narrower range of events or smaller sample size.\textsuperscript{25–27}

In summary, more than half of the CDS alerts in our sample were overridden by providers. While some of the alerts were for formulary substitutions, others warn of potential significant patient harm such as overly high drug dosages given the patient’s renal function or age. Despite their potential for patient harm, these alerts have override rates above 60%. Physicians’ reasons for overriding alerts varied widely depending on the type of alert. Future research should investigate the appropriateness of overrides given the specific clinical context, in order to optimize alert types and frequencies to increase their relevance for patient care, as well as the clustering of overrides by provider in order to design effective interventions aimed at reducing inappropriate alert overrides, which could range from extinguishing unnecessary warnings to targeting physicians with inappropriately high override rates.

\textbf{Contributors} KCN: conception and design, acquisition of data, analysis and interpretation of data, drafting of the manuscript, critical revision of the manuscript for important intellectual content, statistical analysis. KCN had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. SPS: acquisition of data, analysis and interpretation of data. DLS: acquisition of data, analysis and interpretation of data, statistical analysis. LA V: conception and design, acquisition of data, analysis and interpretation of data, critical revision of the manuscript for important intellectual content, obtaining funding, supervision.
REFERENCES