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Think time: A novel approach to analysis of clinicians' behavior after reduction of drug-drug interaction alerts

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ABSTRACT

Objectives: Pharmacologic interaction alerting offers the potential for safer medication prescribing, but research reveals persistent concerns regarding alert fatigue. Research studies have tried various strategies to resolve this problem, with low overall success. We examined the effects of targeted alert reduction on clinician behavior in a resource constrained hospital.
Methods: A physician and a pharmacy informaticist reduced alert levels of several drug-drug interactions (DDI) that clinicians almost always overrode with approval from and knowledge of the medical staff. This study evaluated the behavioral changes in prescribers and non-prescribers as measured by "think time", a new metric for evaluating the resolution time for an alert, before and after suppression of selected DDI alerts.
Results: The user-seen DDI alert rate decreased from 9.98% of all orders to 9.20% ($p = 0.0001$) with an overall volume reduction of 10.3%. There was no statistical difference in the reduction of cancelled (−10.00%) vs. proceed orders (−11.07%). Think time decreased overall by 0.61 s ($p < 0.0001$). Think time unexpectedly increased for cancelled orders 1.00 s which while not statistically significant ($p = 0.28$) is generally thought to be clinically noteworthy. For overrides, think time decreased 0.67 s which was significant ($p<0.0001$). Think time lowered for both prescribers and non-prescribers. Targeted specialists had shorter think times initially, which shortened more than non-targeted specialists.
Conclusions: Targeted DDI alert reductions reduce alert burden overall, and increase net efficiency as measured by think time for all prescribers better than for non-prescribers. Think time may increase when cancelling or changing orders in response to DDI alerts vs. a decision to override an alert.

1. Introduction

At technology enriched healthcare settings the main strategy for reducing drug-drug interactions (DDIs) is to present alerts to prescribers [1,2]. Such alerting includes the expectation of reduced drug prescribing of interacting drugs, and thus reduction in patient harm and other adverse drug events [3,4]. Yet outcomes research reveals that prescribers override (proceed without modification) such alerts as often as 98% of the time [5], implying that DDI alerts have questionable efficacy for achieving their purpose [6].

DDI alerts in many systems are interruptive [7–9], meaning the prescriber must take an action in order to "proceed", "modify", or "discontinue" an order, as opposed to an informational text which does not require the prescriber to do anything and which does not interfere with the ordering workflow. Clinicians abhor interruptions for perceived unimportant alerts. Since clinicians often view the bulk of alerts to be insignificant [6], significant and insignificant alerts become blended. Interruptions of low value possess low signal-to-noise ratio [10], thus clinicians develop information

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overload [6,7,11,12], resulting in alert fatigue [13], increased time burden [14], and annoyance [6,15].

Although there is a paucity of data on the clinical circumstances that lead to significant adverse events, many events are very severe or life-threatening. Experts recommend these DDI alerts be prioritized as mandatory [16]. Other DDIs are lower risk, some even unproven, and recommendations include making such alerts non-interruptive [8].

Alert fatigue is a major source of discontent with electronic health records [17]. There are numerous metrics for alert fatigue. These include the total number of alerts or ratios of alerts to orders [18]; whether they are interruptive or informational [8]; the alert override rate [18]; the proportion of alerts considered irrelevant, inconsequential, or not applicable [3]; and the time it takes to review and act on an alert [14]. Whatever the metric, alert override rates vary from a low estimate of 49% to a more frequently quoted high rate approaching 98% [6]. High override rates carry the risk that clinicians may miss warnings of potentially serious adverse events. That is, if the positive predictive value of an alert is very low, even potentially severe adverse drug-drug interactions may be overridden due to reflexive overriding of alerts [10,19,20].

The most common strategy to combat alert fatigue is to reduce the total burden of events (total alert reduction) (Table 1). Elimination of all but the most significant drug-food interaction alerts, blocking of minor and/or moderate DDIs, and lowering the severity of frequently overridden severe DDIs result in the greatest reduction in the volume of alerts that fire [21]. Some sites tailor alerts such that only major (severe) and contraindicated alerts fire for clinicians, but pharmacists also receive moderate (medium) risk DDI and drug-food alerts [21]. Most sites suppress minor (low) risk alerts (personal communication). Other strategies address redesign of the alerting interface [7].

A comprehensive solution has proved elusive. The science of drug interactions is complex and often requires the knowledge of a pharmacologist. There is often disagreement amongst clinicians regarding the clinical relevance of any given DDI. Drug-drug interaction databases do not classify drugs identically [25,26]. Community hospitals generally lack the services of a team required for thorough analysis of a DDI data base dedicated to the complexities of drug pharmacology, pharmacokinetics, pharmacogenetics, informatics, and therapeutic indications (personal communication). Most also lack the governance structure to analyze the legal implications while minimizing risk to patients [6]. The cost of electronic health records (EHRs), workforce scarcity, and the focus on cost reduction further threaten the likelihood of having such expertise at a community hospital. The informatics challenge, then, is to lighten the DDI alert burden without jeopardizing patient safety, and to avoid potential legal consequences [27].

There is evidence that a plethora of alerts may paradoxically cause as much or greater legal risk as when clinicians do not receive any alerts at all, much like in the airline industry [28]. The optimal positive predictive value has not been established for most alerts [29] nor for that matter has there been a study of the negative predictive value—how many alerts do not fire when they should?

With this background we undertook an examination of our DDI alerting and clinician response patterns. In preliminary evaluations we observed two common scenarios. First, clinicians almost always overrode certain alerts, meaning they proceeded with the drug orders despite the alert. DDI alerts fired even when prescribers ordered guideline-directed drug pair therapy [30] which leads to prescriber consternation. Similarly, non-originators of orders were reluctant to alter drug regimens ordered by specialists. Thus overrides occurred across the board, irrespective of specialty, admitting physician, or diagnosis. Second, clinicians ordered several drug pairs as a safety precaution, such as an opioid and a reversal agent. These alerts fired even from within an order set designed to be used in those scenarios where both drugs would normally be ordered such as patient controlled analgesia. There is no mechanism in our EHR other than to alter the DDI database to suppress such DDI alerts.

The time it takes to resolve an alert is another component of alert fatigue [14]. Our EHR fires an alert when a clinician orders a drug with the potential to interact with an existing drug on the patient's medication list or one ordered during the ordering session, the optimal time during order entry workflow. Our EHR allows us to measure the time interval between appearance of the alert and when the clinician completes all necessary actions to resolve the alert. We call this "think time". We hypothesize that think time reflects the total cognitive load of an alert better than "time to resolution" as used by Russ, et al. [14]. Those authors note that in their system DDI alerts fire twice (the second time at order signature), which may be a safety measure, but which reflects technical order entry time more than intellectual effort. Think time may include other clinician actions such as discussion with colleagues. McDaniel, et al. [31], introduced the term "dwell time" as "the amount of recorded time elapsed. . . from when. . . an alert was presented. . . to when it was dismissed." Think time may differ from this in that in our system the alert does not close until the clinician completes any cognitive actions such as altering an order or discontinuing one of the drug pairs. We prefer to use the term think time which in our view reflects better the total cognitive load inherent in encountering an alert.

We selected drug pairs with pharmacodynamic interactions, that is, where the pairs may have a synergistic, or conversely, an antagonistic action [32]. Local clinicians and pharmacists were in agreement that ordering both was rational, guideline-directed [30], or safety-oriented. Selected drug pairs included an opioid and naloxone; and anticoagulant/antithrombotic combinations frequently ordered together. Based on the preexisting research and our preliminary data we created several *a priori* hypotheses related to suppression of these DDI alerts:

1. Removal of alerts perceived to be unnecessary will result in an overall increase in think time as the proportion of alerts deemed important will rise.
2. Think time will decrease for clinicians but will not vary for non-clinicians. Clinicians are aware of the clinical condition for which they are prescribing, and so cognitively have already decided what drug pairs they will order whereas pharmacists and perhaps others may require greater think time because they are presented with the alert without a priori familiarity with the clinical condition.
3. The targeted groups—those who are the primary originators of the suppressed drug pairs—will experience a rise in think time despite a drop in total alerts as they will be exposed to proportionately more DDI alerts with which they are less familiar, requiring greater inspection. Conversely, non-targeted clinicians would experience a neutral effect on think time since they primarily override these alerts as they are reluctant to alter therapy initiated by specialists.

2. Methods

2.1. Setting

Holy Spirit Hospital—A Geisinger Affiliate, is a 322 bed private, not-for-profit, community hospital sponsored by the Sisters of Christian Charity, serving an urban and suburban population in south central Pennsylvania with approximately 15,000 yearly admissions. Although the hospital conducts a small teaching program, mostly consisting of physician assistant students, a few medical students, and a few residents, attending physicians are