Journal of Critical Care 39 (2017) 156–161

Contents lists available at ScienceDirect

Journal of Critical Care

journal homepage: www.jccjournal.org

Evaluation of medication-related clinical decision support alert overrides in the intensive care unit

Adrian Wong [a,b], Mary G. Amato [a,b], Diane L. Seger [a,c], Sarah P. Slight [a,d,e], Patrick E. Beeler [a,f,g], Patricia C. Dykes [a,g], Julie M. Fiskio [a,c], Elizabeth R. Silvers [a,c], E. John Orav [h], Tewodros Eguale [a,b], David W. Bates [a,g,*]

[a] The Center for Patient Safety Research and Practice, Division of General Internal Medicine and Primary Care, Brigham and Women's Hospital, Boston, MA, USA
[b] MCPHS University, Boston, MA, USA
[c] Partners HealthCare, Wellesley, Boston, MA, USA
[d] School of Medicine, Pharmacy and Health, The University of Durham, Stockton on Tees, Durham, UK
[e] Newcastle University, Newcastle-upon-Tyne, UK
[f] Research Center for Medical Informatics, University Hospital, Zurich, Switzerland
[g] Harvard Medical School, Boston, MA, USA
[h] Department of Biostatistics, Harvard T.H. Chan School of Public Health, Boston, MA, USA

ARTICLE INFO

Available online xxxx

Keywords:
Adverse drug event
Clinical decision support
Critical care
Patient safety
Quality of care

ABSTRACT

Purpose: Medication-related clinical decision support (CDS) has been identified as a method to improve patient outcomes but is historically frequently overridden and may be inappropriately so. Patients in the intensive care unit (ICU) are at a higher risk of harm from adverse drug events (ADEs) and these overrides may increase patient harm. The objective of this study is to determine appropriateness of overridden medication-related CDS overrides in the ICU.

Materials and methods: We evaluated overridden medication-related alerts of four alert categories from January 2009 to December 2011. The primary outcome was the appropriateness of a random sample of overrides based on predetermined criteria. Secondary outcomes included the incidence of adverse drug events (ADEs) that resulted from the overridden alert.

Results: A total of 47,449 overridden alerts were included for evaluation. The appropriateness rate for overridden alerts varied by alert category (allergy: 94%, drug-drug interaction: 84%, geriatric: 57%, renal: 27%). A total of seven actual ADEs were identified in the random sample and where the medication(s) was administered ($n = 366$), with an increased risk of ADEs associated with inappropriately overridden alerts ($p = 0.0078$).

Conclusions: The appropriateness of medication-related clinical decision support overrides in the ICU varied substantially by the type of alert. Inappropriately overridden alerts were associated with an increased risk of ADEs compared to appropriately overridden alerts.

1. Introduction

Clinical decision support (CDS) aims to improve health care by enhancing decision-making in both inpatient and outpatient settings. Medication-related CDS can assist users when ordering medications and provide potential warnings regarding ordered therapy. Despite evidence to support the benefits of CDS in reducing adverse drug events (ADEs), costs, hospital length of stay and patient morbidity and mortality, there is also a growing body of evidence detailing how these alerts or warnings are regularly overridden [1-4]. The incidence of alert overriding is high in the outpatient setting, as demonstrated by an override rate of 52.6 per 100 alerts [3,4]. Only 53% of these overrides were identified as appropriate, defined as a false positive alert (i.e., an alert that was not clinically relevant to the patient). In a Veterans Affairs population, one study found that the override rate of critical alerts was 87% [5]. Explanations for overrides include poorly constructed alerts and alert fatigue [4]. However, CDS overrides may lead to a spectrum of patient harm from no harm to irreversible harm. ADEs have been associated with additional healthcare costs, increased hospital length of stay, and increased mortality [6-9]. However, literature associating CDS overrides with increased patient harm is limited [10-11].

Patients in the intensive care unit (ICU) are particularly susceptible to ADEs. These patients may be at greater risk than general ward

* Corresponding author at: Division of General Internal Medicine and Primary Care, Brigham and Women's Hospital, 1620 Tremont Street, 75 Francis Street, Boston, MA 02115, USA.
E-mail address: dbates@partners.org (D.W. Bates).

http://dx.doi.org/10.1016/j.jcrc.2017.02.027
0883-9441/

patients for a variety of reasons, including altered pharmacokinetics, an increased length of stay and an increased number of medications administered [12-16]. Continuation of a patient's home medications may also be a potential cause of ADEs, given a patient's altered pharmacokinetics. Prospective cohort studies identifying ADEs in the ICU found them to be common, with rates varying from 30.6 to 96.5 per 1000 patient days, associated with morbidity but not associated with increased mortality [17,18]. Given the benefits of CDS, overrides of available alerts may lead to increased risk of patient harm in the ICU.

However, few studies exist evaluating the appropriateness of CDS alert overrides in inpatients and we could not identify previous studies evaluating overrides in intensive care. Therefore, we performed a study to characterize the appropriateness of CDS overrides in the ICU, including their potential association with harm.

2. Materials and methods

This study was a retrospective, observational study evaluating medication-related CDS alert overrides by providers. Alert overrides were generated between January 2009 and December 2011 from patients admitted to an adult ICU at Brigham and Women's Hospital. The alerts targeted were focused on alert types that have a high occurrence and significance in the ICU patient population: drug-allergy, drug-drug interaction (DDI), geriatric (age ≥ 65 years) and renal (creatinine clearance calculated by the Cockcroft-Gault equation) [19]. The proprietary Partners Healthcare System Knowledge Base was used as the basis of the DDI, geriatric and renal alerts, which had been customized over years based on end-user feedback and prospective review of literature [20,21]. Allergy alert logic was sourced from First DataBank (First DataBank, South San Francisco, CA, USA).

A few alerts occurred very frequently and overrides were generally considered appropriate, and these were excluded and therefore considered the "unevaluated" alerts. These were as follows:

- DDI – epidural bupivacaine and anticoagulants ordered appropriately per institution policy, limited systemic absorption, intravenous calcium and ceftriaxone alerts which were intended to fire only in neonatal patients, and alerts involving absorption issues, but with a medication ordered in a parenteral form;
- Geriatric – short-term laxative use;
- Renal – aspirin dosed for cardioprotection (defined as ≤325 mg daily) [22].

The primary outcome was the appropriateness of the remaining overrides, assessed by two independent reviewers with a set of predetermined criteria specific for each type of alert. Secondary outcomes included the documented reason for override and the incidence of ADEs associated with overrides. Outcome evaluation was only completed on the "evaluated alerts" (i.e. alerts that were not excluded as they could be appropriate or inappropriate). This study was approved by the Partners Institutional Review Board.

2.1. Appropriateness evaluation

Criteria for appropriateness were created via previously published data, including guidelines, as well as clinical experience of a multidisciplinary group [23]. Criteria were specific for alert categories and modified until a consensus was reached for all criteria. A random sample of 100 evaluated alerts (termed "random sample") in each of the alert categories was selected for determination of appropriateness. Two clinical pharmacists independently evaluated the appropriateness of overrides. The inter-rater agreement for appropriateness was determined via a κ statistic. Disagreements were resolved via discussion between the two independent reviewers. If consensus was not achieved, a third experienced reviewer was consulted. The κ for the criteria agreement of appropriateness was 0.79 (95% CI 0.73–0.86) indicating substantial agreement, with a percent agreement of 90.6%.

2.2. Override rationale evaluation

A rationale for overriding the alert was required to be provided only for allergy and DDI alerts; override reasons for geriatric and renal medication alerts were optional. Rationale was grouped based on choice from a drop-down menu (i.e. coded reasons), while related free-text entries were grouped together based on patterns. These system-coded reasons were available in the data for evaluation. The override reason, if provided, was also utilized in the appropriateness evaluation (e.g. if a prescriber gave the reason 'will monitor as recommended,' then the medical record was evaluated for related monitoring).

2.3. ADE evaluation

To evaluate for ADEs, we performed patient chart reviews on the random sample of overrides ($n = 400$). In 366 cases, the patient actually received the medication. ADEs were specific to the overridden alert (e.g. amiodarone and levofloxacin DDI, only evaluating QTc and documentation of dysrhythmia). Data relevant to an ADE, such as patient comorbidities, laboratory reports, medication orders and patient notes documented by nurses or providers, were abstracted and summarized by one reviewer. These data were blinded (i.e. appropriateness of override was not provided) and forwarded to two independent reviewers to determine if an ADE occurred (no ADE, probable ADE, definite ADE), the severity of the ADE (significant, serious, life-threatening, fatal) and whether it was considered preventable (non-preventable, preventable). If consensus was not achieved, a third experienced reviewer was consulted. ADEs of inappropriately overridden alerts were defined as preventable, as there was a CDS alert that could have prevented the medication from being ordered. Study personnel had undergone training based on curriculum developed by the Center for Excellence for Patient Safety Research at Brigham and Women's Hospital. This training has been used in previous studies and has been previously described [24].

2.4. Statistical analysis

Descriptive statistics were used to summarize patient and alert characteristics. A chi-square or Fisher's exact test was used to compare categorical variables. An exact binomial calculation was used to determine confidence intervals within the observed samples. Approximate binomial confidence intervals were calculated for the weighted population average ADE rates in appropriately and inappropriately overridden alerts. Because observed ADE rates of 0 in some categories would underestimate the variances, the population weighted rate was used instead. Both an exact Fisher test and an exact Poisson regression, adjusted for alert categories, were used to compare the rates of ADEs between the appropriately and inappropriately overridden alerts in the random sample. A p-value of <0.05 was considered significant. Statistical analysis was completed using SAS 9.3 (SAS Institute Inc., Cary, NC, USA).

3. Results

A total of 59,175 overridden medication-related alerts were fired for patients who were admitted to the ICU between January 2009 and December 2011. A total of 47,449 alerts (80.2%) were considered in our evaluated sample for appropriateness (Fig. 1), and, unless otherwise noted, constitute the analysis sample. Allergy alerts accounted for the majority of CDS overrides (84.4%).

There were a total of 4776 unique patient encounters overall in the study population (Table 1). Patients with overridden geriatric and renal alerts tended to be older than in the other groups, as expected.