The Journal of Emergency Medicine, Vol. 56, No. 1, pp. 109–113, 2019

0736-4679/$ - see front matter

https://doi.org/10.1016/j.jemermed.2018.10.002

Computers in Emergency Medicine

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THE EFFECT OF A CLINICAL DECISION SUPPORT FOR PENDING LABORATORY RESULTS AT EMERGENCY DEPARTMENT DISCHARGE

Brian E. Driver, MD,* Sarah K. Scharber, BS,† Erik T. Fagerstrom, BA,* Lauren R. Klein, MD,* Jon B. Cole, MD,* and Ramnik S. Dhaliwal, MD, JD*

*Department of Emergency Medicine, Hennepin County Medical Center, Minneapolis, Minnesota and †Duke University School of Medicine, Durham, North Carolina

Reprint Address: Sarah K. Scharber, BS, Department of Emergency Medicine, Hennepin County Medical Center, 701 Park Avenue S, Mail Stop R2, Minneapolis, MN 55415

☐ **Abstract—Background: Health care systems often implement changes within the electronic health record (EHR) to improve patient safety and reduce medical errors. Objective: To compare the proportion of emergency department (ED) encounters with laboratory tests resulting subsequent to patient discharge before and after a clinical decision support was implemented. Methods: In 2015, our institution added an EHR dialogue when placing ED discharge orders, requiring providers to declare whether all laboratory results had been reviewed. To determine the effectiveness of this initiative, we searched the EHR to identify the proportion of ED encounters with laboratory tests resulting after discharge in pre- (January to June 2015) and post-intervention (January to June 2016) periods. Results: There were 67,287 discharged patients during the study periods. In the pre- and post-intervention periods, respectively, 6.9% (95% confidence interval [CI] 6.7–7.2%) and 7.9% (95% CI 7.6–8.2%) of encounters had laboratory tests resulting after discharge, with an absolute difference of 0.9% (95% CI 0.5–1.3%). Of these patients with laboratory tests resulting after ED discharge, in 92% the provider inaccurately marked "yes" or "not applicable" to the EHR dialogue prompt. Conclusions: This workflow intervention was associated with an increase in the proportion of laboratory tests resulting after ED discharge; inaccurate answers to the EHR dialogue were pervasive. EHR workflow interventions do not always accomplish their intended goals, and their implementation should be considered thoughtfully.**

☐ **Keywords—electronic health record; clinical decision support; kludge; workflow intervention**

Presented at the 2017 Annual Meeting for the Society of Academic Emergency Medicine in Orlando, Florida, May 2017.

INTRODUCTION

Health care systems often implement changes to provider workflow within the electronic health record (EHR), with goals to improve patient safety and reduce medical error. Clinical decision support (CDS) systems, which provide alerts at the point of ordering, can reduce medication errors and adverse drug events, and improve care (1,2). Clinical reminders, such as best-practice alerts to provide preventive services, are increasingly common in EHRs as a result of demonstrated efficacy in improving rates of evidence-based care (3,4).

Despite the recent increase in CDS systems, it is well recognized that provider exposure to CDS alerts is associated with alert fatigue, which is the desensitization of health care providers to alerts, causing alerts to be ignored or responses to alerts to be delayed (5). Alert fatigue has been studied in relation to both in- and out-of-hospital medication prescribing. Although CDS alerts are thought to be useful in concept, in practice, 49–96% of alerts are overridden, raising questions about the effectiveness of decision support

Received: 27 April 2018; Final submission received: 1 October 2018;
Accepted: 7 October 2018

(6). Furthermore, after-the-fact patches to an EHR to attempt to improve a quality metric do not generally solve the root problem, which is often due to the underlying EHR design; this has sometimes earned these workflow changes the moniker "kludge," defined as "an ill-assorted collection of poorly matching parts, forming a distressing whole" (7). While medication-related CDS alerts have been studied extensively, there have been few studies exploring the effectiveness of CDS in changing provider EHR workflow, particularly in the ED.

In October 2015, our institution added a dialogue during placement of the discharge order that required the provider to state whether all laboratory results had been reviewed, with the goal to remind providers of pending tests.

We sought to determine if the addition of this EHR dialogue at the time of discharge order was associated with a decrease in the proportion of patients who had a laboratory test result after ED discharge.

METHODS

Study Setting

This retrospective before and after observational study was set in an urban academic ED with an annual census of approximately 100,000 patients. A comprehensive electronic medical record tracks patient demographics, ED orders, results, and the timing of all ED events. In 2015, the Minnesota Department of Health and Minnesota Hospital Association released a safety alert warning of adverse events that can occur when ED patients are discharged before the results of laboratory tests are reviewed (8). A "hard stop" in the EHR to prevent patient discharge before laboratory review was recommended for all EDs.

To address this recommendation, an additional step was added when placing a discharge order for ED patients in our institution beginning in October 2015. This step requires the provider to respond to the statement "results of all diagnostic tests have been reviewed" with a selection of yes, no, or not applicable. The local Institutional Review Board at Hennepin County Medical Center approved this study.

Selection of Participants

ED patients discharged between January and June 2015 (pre-intervention period) and January and June 2016 (post-intervention period) were identified by a blinded data analyst.

Data Collection and Processing

For each study period, a blinded data analyst extracted patient age, time of the discharge order, whether any laboratory studies resulted after the discharge order was placed, and if so, the name of the laboratory test. For patients in the after period, responses to the statement "results of all diagnostic tests have been reviewed" were also extracted. These data were given to the investigators for further analysis. Laboratory tests with the word *culture*, *gonorrhea*, or *chlamydia* were excluded from this analysis because of anticipated long turnaround times. All other tests were included.

Outcomes

The primary outcome was the proportion of discharged ED patients with a laboratory test that resulted after the discharge order was placed.

Data Analysis

The proportion of discharged ED patients in each study period with a laboratory test that resulted after the discharge order was placed, the difference between the study periods, and the associated 95% confidence interval (CIs) levels are reported. The response to the statement "results of all diagnostic tests have been reviewed" for patients with laboratory tests resulting later is presented for the after period. The name of the laboratory tests that resulted after ED discharge are presented for both study periods. STATA software (version 12.1, StataCorp, College Station, TX) was used for data analysis.

RESULTS

Main Results

During the study periods, there were 67,287 discharged patients: 33,234 in the pre-intervention period and 34,053 in the post-intervention period. Median age in both periods was 34 (95% CI 33–35) years. In the pre-intervention period, there were 2,303 (6.9%; 95% CI 6.7–7.2%) unique encounters with 3,166 laboratory tests that resulted after discharge; in the post-intervention period there were 2,680 (7.9%; 95% CI 7.6–8.2%) unique encounters with 3,904 laboratory tests that resulted after discharge, with an absolute difference of 0.9% (95% CI 0.5–1.3%). During the post-intervention period, of the 2,680 patients with laboratory tests that resulted after discharge, in 2,469 (92%) patients the provider inaccurately marked "yes" or "not applicable" to whether all tests were reviewed.

The 10 laboratory tests that most commonly resulted after discharge in both study periods are displayed in Table 1.

DISCUSSION

Many EHR systems contain CDS alert systems that are implemented to positively affect provider workflow.

Table 1. Ten Most Common Laboratory Tests Resulting After Discharge

Laboratory Test Name - No. (%)	Pre-intervention (N = 33,324 with 3,166 Laboratory Results after Discharge)	Post-intervention (N = 34,053 with 3,904 Laboratory Results after Discharge)
Complete blood count	215 (6.8)	219 (5.6)
Urinalysis	204 (6.4)	190 (4.9)
Urine drug screen	187 (5.9)	412 (10.6)
Levetiracetam level	140 (4.4)	130 (3.3)
Troponin I	110 (3.5)	105 (2.7)
Beta HCG, serum	95 (3.0)	82 (2.1)
Urine pregnancy test	95 (3.0)	117 (3.0)
Rapid plasma reagin	82 (2.6)	136 (3.5)
Influenza virus antigen	77 (2.4)	109 (2.8)
Hepatic function panel	76 (2.4)	82 (2.1)

HCG = human chorionic gonadotropin.
Number of laboratory tests by type resulting after discharge before and after the implementation of an electronic health record alert prompting providers to review results prior to discharge. The tests are sorted in order of pre-intervention values. Values are raw number of laboratory results and percent of the total number of laboratory tests that resulted after discharge. Human immunodeficiency virus antibody was also in the top 10 resulted laboratory tests resulting after discharge in the post-intervention period (n = 109 [2.8%]).

Historically, there is some literature to suggest that these alerts improve patient safety and reduce medical error (1,2). More recently, there was a review of 23 studies examining CDS alert system implementation between 2000 and 2016. Of these studies, 53% reported a statistically significant benefit, 34% demonstrated no statistically significant benefit, and 6% actually showed detriment after implementation (9). Although extensively studied with regard to medication prescribing, the effects of CDS alerts have not been closely examined for improvements in provider workflow or in the ED.

In the ED, it is common for test results to be pending at the time of patient discharge. Additionally, it may be challenging to follow up on results and reconnect with patients if an important test results after the patient has left the ED, especially in EDs that care for socioeconomically disadvantaged populations without a permanent address or working phone number. In theory, the hard stop implemented at our institution should have reminded providers to review all pending laboratory testing prior to patient departure. In practice, our results suggest that the alert served only as another required mouse click in the discharge process and did not result in a decrease in the proportion of patients who were discharged prior to the review of all laboratory results. In fact, there was an increase in the proportion of patients discharged with pending laboratory results following the implementation of the alert system.

The ineffectiveness of the hard stop is not surprising in the context of prior studies, which show that between 49% and 96% of CDS alerts are overridden (6). It is clear that providers in our institution were simply "clicking through" the hard stop, evidenced by the fact that in 92% of patients with a laboratory result after discharge, the provider inaccurately stated there were no pending tests to review when placing the discharge order. Though the intervention in our institution was not efficacious, some CDS alerts have shown benefit (10). However, any demonstrated efficacy must be balanced against the time required to address the CDS hard stop, among other important factors (7). A simple calculation reveals that 18 h of provider time per year in our ED is spent answering this discharge question, assuming 1 s per patient for the 65,000 that we discharge annually. In imagining implementation of similar hard stops for other common clinical problems (e.g., vital sign abnormalities at discharge, wrong patient ordering, tetanus vaccination, considering non-accidental trauma in an injured child, ad infinitum), it is obvious that this type of "kludge" does not scale well (7).

It is undeniably important to review the results of important laboratory tests before the patient leaves the ED; therefore, it is important to build EHR systems so that this is easily and expeditiously accomplished. In retrospect, this workflow intervention could have been designed to better serve ED providers, given their frequent task interruption and propensity of physicians to click through alerts (11,12). An alert listing pending laboratory results on a discharge screen would provide potentially useful information without requiring action from the discharging provider. Furthermore, due to alert fatigue, it would be desirable to exclude certain tests that commonly result after discharge (eg, culture results) from this type of alert, so providers would be more likely to take the alert seriously. Even better would be the careful construction of EHR systems from the ground up to address commonly encountered EHR and clinical problems, rather than tacking on solutions after the fact (7).

Limitations

In this study, we were unable to differentiate between laboratory tests important to result during the encounter and those intended to result after discharge for follow up at a later time. This limitation applies to both the pre- and post-intervention time periods. Additionally, it is possible that a patient's condition resolved prior to the laboratory tests resulting and they were no longer necessary to review before discharge and our study did not identify these situations. Another limiting factor arises in that the

primary outcome of this study was an aggregate proportion of all pending laboratory tests at discharge. Examination of individual laboratory tests could potentially show differences between results that providers were intending to review prior to discharge (e.g., troponin) and those that they were planning for other providers to review at a later time (e.g., urine drug screen).

CONCLUSIONS

In summary, the implementation of a CDS hard stop to improve provider workflow for pending laboratory results at time of ED discharge was ineffective, and an increase in laboratory tests resulting after discharge was found during the intervention period. CDS interventions do not always accomplish their intended goals, and their implementation should be thoughtfully and carefully considered.

Acknowledgments—We thank Marty Henkemeyer for his assistance with data collection.

Author contributions: BED, ETF, JBC, LRK, and RSD conceived and designed the study and collected the data. BED performed the data analysis. BED, SKS, and RSD drafted the initial manuscript, and all authors contributed substantially to its revision. BED takes responsibility for the study as a whole.

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ARTICLE SUMMARY

1. Why is this topic important?

Since the increase in reliance on the electronic health record (EHR), there have been many efforts to implement electronic workflow interventions to improve patient care. There have been mixed results reported on the efficacy of these interventions.

2. What does this study attempt to show?

The study attempts to evaluate the efficacy of a simple EHR workflow intervention in the emergency department (ED) intended to reduce the number of laboratory tests resulting after patient discharge.

3. What are the key findings?

An EHR alert requiring physicians to review pending laboratory results at the time of ED discharge did not reduce the proportion of patients discharged with results pending. Of patients with laboratory tests pending at discharge, 92% of providers inaccurately indicated that all tests had been reviewed. EHR workflow interventions do not always accomplish their goals and should be considered carefully.

4. How is patient care impacted?

Patient safety was not improved with a simple EHR workflow intervention. Assuming intervention takes 1 s per patient, 18 h of provider time annually is spent on this ineffective implementation. Providers overwhelmed with EHR alerts may not pay attention to them all.