Use of Targeted Computerized Alerts to Address Potential Adverse Drug Events at a Large Community Health System

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BACKGROUND

Banner Health is a 23-hospital community health system serving the western United States, with facilities in Arizona, Colorado, Nevada, Wyoming, California, and Nebraska. Banner Health operates a longitudinal electronic medical record (EMR) system complete with computerized prescriber order-entry (CPOE). Implementation of CPOE was done in a step-wise fashion and recently completed for all Banner hospitals. The medical and clinical informatics departments, working under the chief medical information officer (CMIO) are responsible for CPOE implementation, including development of standardized order sets and electronic alerts to facilitate a safe and effective medication-use process for the system.

Prior to the implementation of CPOE, various attempts were made to develop a system-wide computerized adverse drug event (ADE) prevention program at Banner Health. These attempts were limited by high false-positive rates, technological limitations, and inconsistent support of administrative and clinical personnel. Technological limitations contributed to alerts with high false-positive rates. This was largely the result of criteria that were too loose, leading to very sensitive alerts that lacked specificity. The primary adverse consequence of high false-positive rates is alert fatigue among providers and pharmacists. Alert fatigue occurs when clinicians are presented with an excessive amount of alerts that interrupt workflow. It is exacerbated when the alerts that are presented have a low probability of necessitating an intervention. In this situation, clinicians tend to start ignoring all alerts, including those that could prevent an adverse patient event. The end result is a system that does not improve patient safety, but decreases the morale of clinicians. During previous iterations of our ADE prevention program, alert fatigue led to inconsistent support of clinical and administrative personnel. The success of any ADE prevention program is dependent on the buy-in of clinicians and administrators at all facilities and levels of the system.

Our objective was to improve our existing ADE prevention program by targeting specific clinical scenarios, allowing us to turn off more sensitive/less specific drug-drug interaction (DDI) alerts provided by our EMR vendor, effectively reducing alert fatigue by decreasing the total number of alert pop-ups to providers and pharmacists. Key to the success of this program is the ability to prioritize alerts and direct them more easily to the appropriate clinical personnel. Physicians are only presented with urgent alerts requiring immediate action, while all other alerts are sent to pharmacists for evaluation.

METHODS

Within the medical informatics department, the Discern pharmacy program manager is tasked with leading a group of clinical pharmacists with the goal of continuously improving the ADE prevention
program at Banner Health. Each facility in the system has at least one pharmacist in the ADE group to ensure system-wide representation and input. The ADE group meets monthly to discuss requests for new alerts, efficacy of current alerts, and ways to improve the current alerting and documentation process. Input for potential alerts comes from both providers and pharmacists. Prior to implementation, alerts are tested, validated, and refined based on physician and pharmacist feedback. Educational materials are then developed and distributed to personnel affected by a new alert including providers, pharmacists, and nurses. Educational materials include workflow tip sheets, screen shots of new alerts, and system-developed clinical practice guidelines. On-going assistance with alerts and troubleshooting is provided by facility-level clinical informatics coordinators as well as corporate-level personnel within the medical informatics department. Once an alert is activated, vendor-provided DDI alerts are often turned off when our custom alert provides more specific advice.

ADE prevention alerts are prioritized based on urgency of the problem. Only situations in which an urgent intervention is deemed necessary to prevent patient harm are selected to appear on-screen and interrupt physician work flow. All other alerts are designated to print out to pharmacists in real-time. Pharmacists evaluate and, if necessary, act upon the alerts to initiate a change in therapy. A number of system-wide protocols have been developed to allow pharmacists to make appropriate interventions without the need for prescriber contact in many scenarios. These include renal and hepatic dose adjustments, formulary substitutions, intravenous to oral dosing interchanges, and ordering of necessary labs for monitoring therapeutic outcomes.

A custom website was created to allow pharmacists to document all printed alerts and record therapeutic interventions, allowing for real-time tracking. All alert firings are automatically populated on the website and remain there until documented by a pharmacist. All pharmacists have access to the documentation website and can check the status of any ADE prevention alert at any time. The documentation website allows data to be extracted and used to analyze the effectiveness of the ADE prevention program.

Antimicrobial stewardship alerts were developed to decrease inappropriate utilization of high-cost antibiotics at Banner Health. Appropriate use criteria for each antibiotic class were developed based on the recommendations of the system infectious disease clinical consensus group. Stewardship alerts were created for carbapenems, echinocandins, amphotericin B, linezolid, daptomycin, and tigecycline. These alerts are made to fire on-screen to the provider each time a non-formulary antibiotic is ordered. To continue with the order, the provider must document the necessity of the agent by selecting one of the
listed criteria. If the provider continues with the order, a printed alert will be sent to pharmacy for further review. An example of a stewardship alert is shown in Figure 1.

Figure 1: Example Antibiotic Stewardship Alert

**DISCERN INFECTIOUS DISEASE ALERT: ANTIMICROBIAL STEWARDSHIP MICAFUNGIN**

The following message was an on-screen alert for micafungin 01/01/2012 12:00:00

"Pharmacy and Therapeutics Committee has limited the use of micafungin to oncology, documented non-fluconazole susceptible infection, positive blood culture for yeast, empiric therapy in severe sepsis with one risk factor or sepsis with two risk factors. Risk factors include TPN, surgery this admit, candida colonization, central line >10 days.

Approximately 90% of Candida isolates are fluconazole susceptible. Recommend fluconazole 800 mg now and 400 mg daily for normal renal function.

**The order and ordering physician:**
PHYSICIAN, TEST

**Reason for Override (if available):**
Sepsis with TPN & central line >10 days

**Reasons for documentation:**
Criteria 1: Oncology, hematopoietic stem cell transplant
Criteria 2: Transfer to facility on echinocandin - micafungin authorized for 24 hours only
Criteria 3: Treatment of documented non-fluconazole susceptible fungal infection
Criteria 4: Sepsis and two of the following (TPN, surgery this admit, candida colonization, central line >10 days)
Criteria 5: Severe sepsis and one of the following (TPN, surgery this admit, candida colonization, central line > 10 days)
Criteria 6: Yeast identified in blood culture

**RESULTS**

A total of 232 alerts have been developed to date, 30 of which appear on-screen to providers. Categories of alerts include renal-dosing, drug-lab interactions, drug-disease interactions, antimicrobial stewardship, over- and under-dosing, FDA MedWatch, formulary management, and anticoagulation monitoring. In 2011, a total of 51,240 alerts were printed to pharmacy as a result of this program. The documentation rate of these alerts was 97%, representing an improvement over 2010 (94%). A total of 12,039 alerts (24%) resulted in a change in therapy to lessen the probability of an ADE. This was significantly higher than 2010 (17%) and represents a substantial reduction in false positive rate compared to vendor-provided DDI alerts. Of the 12,039 therapeutic interventions, 6,285 (52%) occurred as part of a pharmacist-driven protocol. The acceptance rate of all ADE prevention alerts by providers was 78% in 2011. The most common reasons given for non-acceptance of alerts by providers were
“patient stable” and “patient pending discharge”. Figure 2 contains an example summary report of ADE prevention alert activity at Banner Health in 2011.

**Figure 2: 2011 Summary of ADE Prevention Alert Activity at Banner Health**

**SUMMARY BANNER HEALTH DISCERN CLINICAL ALERTS**

<table>
<thead>
<tr>
<th>Total Rule-Firings</th>
<th>51,240</th>
<th>Recommendation Accepted</th>
<th>78.41%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Documented</td>
<td>49,377</td>
<td>97.34%</td>
<td></td>
</tr>
<tr>
<td>Total Change in Therapy</td>
<td>12,071</td>
<td>24.20%</td>
<td></td>
</tr>
</tbody>
</table>

The creation of smarter alerts for certain clinical scenarios has allowed the discontinuation of several on-screen vendor-provided DDI alerts. Two examples that were evaluated are hyperkalemia DDIs and thrombocytopenia DDIs.

Our vendor-provided DDI program fires an on-screen alert for a DDI (citing a risk for hyperkalemia) every time two drugs in the following classes are present in the medication profile: angiotensin-receptor blockers (ARBs), angiotensin-converting enzyme (ACE) inhibitors, spironolactone, and potassium salts, whether alone or present in intravenous fluids. These criteria resulted in a total of 2336 annual firings prior to the initiation of the smarter alert. The ADE prevention group developed a more specific alert that only fires when a medication with hyperkalemia potential is ordered AND the
patient’s most recent serum potassium is greater than 6 mg/dL. Patients with a serum creatinine greater than 3 mg/dL are excluded. These more specific criteria resulted in a total of 456 firings over a one year period, representing an 80% decrease in firing rate.

Our vendor-provided DDI program fires an on-screen alert for a DDI each time two agents that can cause thrombocytopenia and increased bleeding risk are ordered on a patient. This includes any combination of anti-platelet agents. These criteria resulted in a total of 53,835 annual firings prior to the initiation of the smarter alert. The ADE prevention group developed a more specific alert that fires only when an agent associated with thrombocytopenia is ordered and the patient has a recent platelet count of less than 50,000/mL. These more specific criteria resulted in a total of 276 firings over a one year period, representing a 99.5% decrease in firing rate.

The antimicrobial stewardship alerts have been active for three months, accounting for 1,859 alert firings. A total of 265 (14%) orders were cancelled; the remaining orders were completed with an override reason. Anecdotally, the stewardship alerts have been incredibly helpful to pharmacists and facility pharmacy and therapeutics committees who are tasked with the ongoing monitoring of antimicrobial prescribing patterns. Actual cost-savings figures are not yet available, but are being evaluated on a facility and system level.

CONCLUSIONS

The development of a targeted, multi-disciplinary approach for more appropriate alerting to clinicians related to medication therapy-related concerns has led to increased specificity of alerts, a net reduction in the number of alerts interrupting physician workflow and improved acceptance and documentation of changes in therapy resulting from alerts. This type of alerting system has proven to be beneficial for adverse drug event prevention as well as anti-microbial stewardship. The ability to prioritize alerts is critical to the success of the program. Establishing a hierarchy of alerts such that only urgent alerts requiring immediate intervention appear on-screen to providers is essential to obtaining support from clinicians and administrators. Providing a documentation website for pharmacists to document and track alerts real-time has improved the efficiency with which alerts are processed and interventions can be made, tracked, and communicated. Future applications of this alerting program include development of advanced on-screen clinical decision support alerts for problematic agents or clinical scenarios. Examples include appropriate use of erythropoiesis stimulating agents and appropriate venous thromboembolism prophylaxis for inpatients.
Danny McNatty, Pharm.D.,BCPS is a pharmacy program manager within the medical informatics department at Banner Health in Phoenix, AZ. Danny received his Pharm.D. from SUNY at Buffalo and completed a two-year post-graduate residency in pharmacotherapy practice at Texas Tech University Health Sciences Center. His interests include informatics, adverse drug event prevention, pharmacy education, and continuous professional development.

Brenda Stoffer, RN is a Clinical Decision Support program manager within the medical informatics department at Banner Health in Phoenix, AZ. Brenda received her BSN from Arizona State University and worked in trauma/ED/ICU for several years before becoming interested in quality improvement and informatics. Brenda has devoted her last 10-15 years to using information technology to improve healthcare quality.

Nick Sindorf, MISM, MT, CLS is a Clinical Decision Support program manager within the medical informatics department at Banner Health in Phoenix, AZ. Nick completed a Masters degree in Information Systems Management with an emphasis in Healthcare Management from Keller University and completed a Bachelors degree and internship in Clinical Laboratory Sciences from Rockhurst University and Saint Luke’s Hospital in Kansas City, MO. At the beginning of his career Nick was immediately interested in Laboratory Information Systems and has expanded his knowledge to the entire electronic medical record, clinical decision support, and data mining/analysis.

Joel McAlduff, MD was the Chief Medical Information Officer at Banner Health at the time of this work. He is now the Vice President – Chief Medical Information Officer at MedStar Health in Columbia, Maryland. Dr. McAlduff is a graduate of Arizona State University (B.S. Microbiology) and The University of Arizona (M.D.). He completed postdoctoral Fellowship training in Medical Informatics through Harvard University/Massachusetts Institute of Technology at the Laboratory of Computer Science, Massachusetts General Hospital. He is Board certified in internal medicine.