Using Medication List – Problem List Mismatches as Markers of Potential Error

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ABSTRACT

The goal of this project was to specify and develop an algorithm that will check for drug and problem list mismatches in an electronic medical record (EMR). The algorithm is based on the premise that a patient's problem list and medication list should agree, and a mismatch may indicate medication error. Successful development of this algorithm could mean detection of some errors, such as medication orders entered into a wrong patient record, or drug therapy omissions, that are not otherwise detected via automated means. Additionally, mismatches may identify opportunities to improve problem list integrity. To assess the concept's feasibility, this study compared medications listed in a pharmacy information system with findings in an online nursing adult admission assessment, serving as a proxy for the problem list. Where drug and problem list mismatches were discovered, examination of the patient record confirmed the mismatch, and identified any potential causes. Evaluation of the algorithm in diabetes treatment indicates that it successfully detects both potential medication error and opportunities to improve problem list completeness. This algorithm, once fully developed and deployed, could prove a valuable way to improve the patient problem list, and could decrease the risk of medication error.

INTRODUCTION

Background and Significance

A study by Ernst and Grizzle in the Journal of the American Pharmaceutical Association indicates that drug misuse costs the economy more than $177 billion a year [1]. In fact, the costs associated with drug-related problems exceed the costs of medications themselves. More important is the human impact of medication errors, as indicated in the recent Institute of Medicine report, To Err is Human [2], and its follow up report, Crossing the Quality Chasm [3].

Problems with medications typically fall into one of eight categories: untreated indications, improper drug selection, sub-therapeutic dosage, failure to receive drugs, over-dosage, adverse drug reactions, drug interactions, and drug use without indication [4]. A host of advantages for clinician order entry have been described [5,6,7,8,9]. Alert and reminder systems to help identify drug interactions, therapeutic duplications, and drug-allergy contraindications have been proven to have value in reducing medication error [5]. However, automated systems that check for untreated indications, failure to receive drugs and drug use without indication are not common. Clinician and patient diligence is typically relied upon to uncover these problems.

Indeed, the Physician Order Entry Team (POET) at OHSU has identified in their research data a recurring problem in clinician order entry environments: the possibility of inadvertent entry of patient orders for the wrong patient [10]. Other studies have also identified such a source of error in the clinician ordering process [11,12,13,14]. Visual cues ordinarily encountered with the paper record (chart thickness, location, and handwriting recognition) are eliminated in POE environments and the wrong patient entry problem can be insidious. The problem may be recognized and corrected either at the time of order entry, later by the ordering clinician or other clinicians involved in the medication use process, or may go entirely unrecognized, potentially causing patient harm.

This error may occur when the ordering clinician fails to change to a new patient after work is completed on a current account, fails to recognize a difference in similar names, selects the wrong patient in adjoining beds, or deletes or adds digits when entering a patient record by account or medical record number.

Bar Code Medication Administration, where medications are scanned and matched with a patient's bar-coded wristband, has been proposed as a way of preventing inadvertent medication administration to the wrong patient. However, this technology will fail to stop a medication being given to the wrong patient *if the person ordering the medication enters orders into an EMR for the wrong patient.*

Current Detection of Wrong Patient Orders

It is important to note that wrong-patient order entry errors already occur with existing (non-POE) computerized medication management systems. However, many are detected in current order entry environments because order transcription from the paper chart to the pharmacy system, and ultimately to the Medication Administration Record (MAR), is double-checked by nursing personnel. These double-checks are done before the administration of a new drug, and during once-daily review and verification of MAR contents with written orders. When mismatches are detected, they are communicated to the pharmacist by the nurse, and then verified and corrected.

It must be stressed, however, that in POE environments, it is unclear what role the nurse or other agent will play in verification of orders after they have been entered by the physician [15]. There may be few, if any other information sources to double-check before a nurse administers a POE-entered drug in good faith.

Intervention Description and Implications

The patient medication list can be viewed as a snapshot of a patient's condition to the trained eye; a snapshot that should agree with a patient's problem list. Detecting medication list – problem list mismatches using an EMR-based query tool may therefore serve as a helpful way to not only identify wrong-patient order entry errors, but also to verify problem list integrity. A number of different potential error types may be revealed by such a query tool (See Table 1).

METHODS

Model Design and Development

A number of uncoded and coded patient medication and problem list information sources are available in an inpatient setting. Increasingly, the EMR's pharmacy management system is relied upon for comprehensive recording of medication orders.

Table 1. An Analytic Framework

	Patient has disease	**Patient does not have disease**
Drug (+) **Problem List (–)**	cause: • problem list incomplete • no problem list	cause: • order entered for the wrong patient • drug being used for inappropriate indication • failure to discontinue the drug (condition no longer exists)
Drug (–) **Problem List (+)**	cause: • error of omission • accidental discontinuation • problem being managed by other interventions	cause: • problem no longer exists and should be deleted from the list • problem list indicates disease but there is none

Whereas computerized medication order entry serves as a unifying repository for medication information, there may be no similar unifying home for problem list information in the EMR. Problem lists may be found in a number of different places both within and outside of the medical record. Although ICD-9 codes are a potentially rich source of coded problem list information, they are not assigned until discharge at most health systems, making prospective use of this data impossible *during* a patient admission.

Nursing Assessments also contain an abstraction of problem list information. Nurses prospectively assess and record both chronic and acute conditions very early in a patient admission. "Online charting" of nursing assessments directly into the EMR makes this coded data accessible and potentially valuable.

The IDX LastWord System (IDX Systems, Burlington, VT) is the EMR currently employed at all Legacy Health System Portland hospitals including Legacy Good Samaritan Hospital and Medical Center (GSH). Drug data are coded using the Hierarchical Ingredient Code List (HICL) classification system. All drugs within a single therapeutic category (e.g. all antidiabetic drugs) share a common prefix within the hierarchy, and are therefore identifiable as a class. Within the hierarchy, all diabetic drugs are coded as "C4**" (where ** indicates final 2-4 digits/letters of the HICL code for a specific drug).

Because there is no coded electronic problem list in use at GSH, the online Nursing Adult

Admission Assessment was used as a proxy for the problem list. The nurse assessment structure expands to allow documentation using check boxes. Comment fields within this dialog allow further enumeration of a disorder. A consistent finding code is recorded whenever the assessing nurse selects the check box for a disease finding.

The algorithm under study was specified to recognize mismatches in diabetes treatment. Medications used in the treatment of diabetes are easily enumerated, and the risks of receiving treatment in error or not getting treatment when it is needed may be significant. Queries matching HICL and nursing assessment codes were performed using "Enform", a Tandem query routine incorporated into LastWord.

Evaluation

After initial specification, the algorithm first scanned the records of all patients discharged on a single day (chosen at random) to verify its performance. Of the records scanned, the first five drug-positive / problem list-positive matches and first five drug-negative / problem list-negative matches were examined in detail. Additionally, a detailed examination of all *mis*matches revealed in that day's data was done. Any modifications required to improve algorithm performance would have caused a re-test against these test cases to occur during this initial testing phase.

During the second evaluation phase, all patients discharged from GSH during two consecutive months were retrospectively queried for drugs and nursing assessments indicative of diabetes. The investigator personally examined the patient records for all mismatching cases following a prescribed protocol. Data collection and analysis for patient records with mismatches during this phase proceeded in a manner identical to the first evaluation phase. Mismatches were classified into a taxonomy that grew organically as additional mismatch causes were identified.

RESULTS

During the initial study, the algorithm analyzed the records of all 35 patients discharged from GSH on October 25th, 2001. Four mismatches were detected. Of the 31 *matching* records, 26 matched because neither a diabetes drug, nor an assessment indicating diabetes, was detected. The remaining five matches were diabetes drug-positive / diabetes assessment-positive matches

During the initial evaluation phase, detailed examination of the *mismatching* records confirmed that both drugs and assessments detected by the algorithm were detected accurately. Similarly, all records with drug / disease *matches* were confirmed to have matched accurately. Since this phase of the evaluation did not demonstrate any algorithm failures using this small set of patient records, the second evaluation phase was initiated.

To evaluate performance and clinical value in an actual patient care environment, the algorithm retrospectively queried the records of all patients discharged from GSH during October and November of 2001. A total of 2,221 patient records representing 10,360 patient-days of data were queried. Drug – assessment mismatches were detected in 251 records (11.3%) during this period, equivalent to 4.11 mismatches per day. Of these, 162 resulted because a patient had a drug treatment for which there was no corresponding problem and the remaining 89 were mismatches where the nursing assessment indicated a problem for which there was no corresponding drug treatment.

Of 251 total mismatches detected, 226 (90%) mismatches detected were true mismatches, and twenty-three (9.2%) mismatches resulted due to algorithm failures. Conclusions could not be made for two patient records: the paper charts for these patient records were not available for review.

134 mismatches (52.3%) were potentially clinically valuable (if detected, could have had a potential impact on current or future care to that patient) (see Table 2).

Table 2. Potential Clinically Valuable Mismatches

	Total
Medication Errors	
Order entered for the wrong patient	**2**
Potential error of omission (no order written to continue treatment)	**1**
Error of omission (order written – pharmacy failed to enter)	**9**
Opportunities to improve problem list	
Assessment incomplete	**50**
No assessment done	**55**
New onset diabetes (during admission or newly detected)	**12**
Nursing assessment inaccurate (diabetes indicated in non-diabetic patient)	**5**
Total	**134**

The remaining 92 mismatches represented either mismatches that were not clinically valuable, or ambiguous assessment entries (in some cases the check box for diabetes was *not* checked but "IDDM", "type2", or "yes" was placed in the comment line) (see Table 3).

Table 3. Mismatches that were not Clinically Valuable

	Total
Assessment Entry Artifact	
Ambiguous assessment entry	27
Appropriate Use of Drug in Non-Diabetics	
Total Parenteral Nutrition-induced hyperglycemia	11
Steroid-induced hyperglycemia	9
Peri-operative insulin use	13
Stress-induced hyperglycemia	1
Hyperkalemia	2
True Diabetics - Treatment Withheld	
Problem being managed by other interventions	23
Short stay - no drugs administered	4
All oral medications being held	2
Total	92

There were 23 query failures or errors (false positives). The algorithm failed to detect the drug in 19 of these cases. The four remaining failures were instances where the algorithm failed to detect an existing and accurate assessment.

DISCUSSION

While identification and use of HICL codes as the medication data entity was straightforward, selection of a candidate problem list data entity was not. The use of coded online nurse assessment data as a proxy for a formal problem list, while not without some problems, proved an effective solution. Use of these data as a practicality permitted validation of the medication list – problem list matching concept to proceed.

The algorithm proved useful in detecting orders entered for incorrect patients (the original impetus for the algorithm). While only two such errors were found, detection of this error type is significant. Wrong-patient drug administration, especially with drugs used in diabetes treatment, is a potentially devastating error. Detection of two wrong-patient errors during this two-month study period may imply this error takes place twelve times annually within diabetic patients alone at GSH.

Medication omission errors also proved detectable using this tool. Omission errors may result when a physician fails to write an order for a needed drug, or because a duly written order is never transcribed into the pharmacy system. Though transcription tasks in the medication administration cycle are minimized in POE environments, they will likely not be totally eliminated. Verbal orders taken by nurses and other clinicians will require a transcription step. Pharmacy order changes precipitated by the need to change drug formulations to make an order "right" with current inventories or automated devices will also involve a transcription step. Any transcription processes will remain potential opportunities for error.

The preponderance of mismatches detected were issues of problem list integrity; either incomplete assessments or assessments that were not done. This finding has interesting implications for health systems that either already have formal coded problem lists in their EMR's, or are considering their use. Problem list verification using the medication list as an internal crosscheck may prove a useful method to ensure their completeness and accuracy.

Fifty-one patients had no nursing admission assessment done in electronic form. Adult admission assessments for patients admitted directly to the Intensive Care Unit (ICU) are still done in paper format at GSH. Direct ICU admissions may have represented a significant proportion of these "no assessment" mismatches.

Some mismatches resulted for reasons other than problem list deficiencies or medication errors, and were not clinically valuable. These mismatches resulted due to either ambiguous assessment entry, appropriate use of diabetes drugs in non-diabetics, and cases where treatment was being judiciously withheld in true diabetics. These cases underscore the importance of a clinician's cognitive work to assess the importance of each reported mismatch, and point to areas where the algorithm rules might be modified to make the tool's output more useful.

There were 23 query failures (false positive mismatches) detected during evaluation. The majority (19) were caused by a failure to detect a drug that was correctly entered into the EMR. As designed, the algorithm detects drugs via drug charges to a patient account. Where an order was entered for a drug but no charge accrued (e.g. drug never used and credited after discharge, patient's own medications used), these entries were rendered undetectable by the query.

Four query failures resulted when existing admission assessments were not detected. A single assessment finding code, 2083 (diabetes) was shared by four of five nursing assessment entry dialogs, and served as the basis for the query. However, the Behavioral Health Assessment used a different synonymous finding code, 3021 (diabetes), and was not recognized.

This query tool will likely not initially be employed as a real-time alert at the time of order entry. Such an alerting mechanism might prove too disruptive at this early stage of development. However, if properly integrated into the work process of a physician, nurse, or pharmacist, this application might eventually prove valuable as a real-time alert. The vision for the tool in the shorter term is that it would create a once-daily report of mismatches discovered for all hospital inpatients. The results of the report would be available for review, either by the prescriber or other clinician (e.g. pharmacist or nurse) for follow up. Additionally, implementing the algorithm to run its report on a daily basis, rather than on a per-admission basis as was done in this study, may positively impact results and clinical value of the system.

Ultimately, the system might be scaled to also search for mismatches in other disease states, such as hypertension, depression, seizure disorder, hypothyroidism, congestive heart failure, hyperlipidemia, and infectious diseases.

CONCLUSION

This proof-of-concept study successfully demonstrated that a novel matching algorithm that compares a patient's medication list and problem list can be developed and used to benefit patient care. The matching algorithm is a valuable way to identify clinically valuable mismatches, such as those arising due to medication error or deficiencies in problem list integrity. The medication error types that are detectable by this check are not otherwise detected by commonly employed medication decision support functions. This work also demonstrated the potential value of using nursing assessment data, a coded data source that may already be in place in many settings, as a source of actionable problem list information in an EMR. Exploration of the system's usefulness in construction and validation of dynamic problem lists, and its scalability to detect medication errors in other disease states and therapeutic categories make this a concept on which a myriad of future research work might be based.

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