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CLUSTERING AND PRIORITIZING PATIENT SAFETY ISSUES DURING EHR IMPLEMENTATION AND UPGRADES IN HOSPITAL SETTINGS

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Abstract

Our aim was to elicit, label, and prioritize clusters of de-identified patient safety issues experienced during the implementation and upgrade installations of Electronic Health Records (EHRs) in hospitals. Conference participants included clinical personnel (physicians, nurses, pharmacists), human factors experts, patient safety experts, information technology experts from vendors and hospitals, academic experts, graduate students, and other attendees. De-identified reports of patient safety issues were shared via share4safety@gmail.com by conference and non-conference attendees before and during a 90-minute session featured at the Human Factors in Healthcare International Symposium on March 8, 2017. One submitted example of a reported patient safety issue was provided to the group. During the session, each attendee shared with a partner five concerns and identified their top concern. Subsequently, each two-person group shared with the larger group these issues, which were written by a facilitator onto sticky paper and placed on the walls. The issues were grouped using pre-defined categories and new categories were identified. Next, each participant voted for the highest priority cluster and/or individual patient safety issue using stickers. This paper reports the results of the interactive session, including the labeled and prioritized clusters and illustrative examples for each cluster. These clusters may inform reporting systems and quality improvement initiatives with health information technology where choices made during implementation and upgrades as well as design flaws with EHR technology both contribute and interact to produce potential patient safety issues.

INTRODUCTION

Our aim was to elicit, label, and prioritize clusters of patient safety issues experienced during the implementation of Electronic Health Records (EHRs) in hospitals, as well as during upgrades of EHR installations. Insights from these activities may prove useful for patient safety reporting systems and quality improvement initiatives related to health information technology choices during implementation and EHR upgrades.

REVIEW OF CLASSIFICATION STRATEGIES

In order to aid the clustering of reported patient safety issues, several classification strategies were reviewed. These represent a convenience sample based upon prior experience and knowledge of the literature.

First, the clustering strategy used by the Veteran's Health Administration's (VHA's) Office of Information's Patient Safety Program Office (PSPO) was reviewed. The PSPO is a recognized leader in the use of a reporting system to improve patient safety with the use of health information technology. For example, the VHA received the prestigious Eisenberg Patient Safety Award in 2002 for developing and implementing a systems-approach to error reduction within VHA's 163 hospitals. The VHA was one of the first organizations to institute a national error reporting system, the Patient Safety Reporting System (PSRS), inspired by the Aviation Safety Reporting System (ASRS). Because our focus is EHR implementations and upgrades, we looked at the reports of patient safety issues which specifically identify incidents, near-misses, or close calls related to software programming deficiencies. This formal Patient Safety Program Office (PSP) systematically advances the state of the art in use of a reporting system as a vehicle to improve patient safety through emphasis of analysis, testing, and feedback as part of the software engineering process. The program emphasizes:

- Reporting unsafe conditions rather than errors, undesired outcomes, desired software enhancements, or software "glitches"
- Gathering stories from a clinical perspective, not just details of the technical glitches
- Receiving reports from more than one clinical "stovepipe" or work group
- Utilizing human-factors engineering expertise extensively throughout the data collection, analysis, and system redesign process
- Employing a systematic approach for prioritizing change initiatives
- Simultaneously pursuing short-term and long-term solutions
- Tracking implemented solutions
- Involving clinical and operational stakeholders in identifying and addressing IT-related patient safety issues
- Providing training and education for health care IT staff to establish a culture of safety
- Disseminating information about IT-related best practices for patient safety.

Patient safety issues (PSIs) are tracked by Online Information (OI) using the National Online Information Sharing ("NOIS") system (later called the Remedy Help Desk) an application that is part of the VistA computerized environment and then entered through the OI Patient Safety Internal Notification Form, which includes fields to enter a description of the problem, specific incidents that occurred, harm to patients, the site where the problem was identified, among others. Each patient safety issue (PSI) is monitored by the Office of

Information Patient Safety Workgroup, which consists of a safety analyst, health information management specialist, IT specialists, and functional analysts—many with nursing, medical, pharmacy, or laboratory expertise. The workgroup monitors each PSI through an email distribution list, discussing issues via email and on conference calls. The workgroup then decides on what actions to take to eliminate or reduce the concerns. This approach results in incremental and iteration-based improvement in software (often in the form of a software “patch,” a modular chunk of code that updates existing software packages upon installation).

Each PSI is assigned a tracking number by VHA OI with limited basic information recorded, such as data reported, VistA application(s) affected, and resolution. The classification scheme in Table 1 was used at one time to group common patterns in PSIs reported over a one-year period soon after the system was implemented. Since that time, it is unclear that this classification scheme has continued to be used, partly due to human factors concepts not being particularly intuitive for many clinical personnel.

Similarly, Table 2 was used to analyze reported PSIs over a one year period by type of risks. “Communication Risks” and “Clinical Data Risks” each had several associated sub-themes.

Second, Menon, Singh, Sittig and colleagues (2016) published a taxonomy that they used to organize 245 EHR-related safety concerns reported during Safety Huddles. For each of the dimensions, they categorized incidents by: 1) EHR technology not working at all, 2) EHR technology working incorrectly, 3) EHR technology missing or absent, and 4) EHR-related concerns linked to user errors. The other dimensions were:

1. Hardware and software: subcategories hardware malfunction, device failure, incompatibility between devices, software malfunction, software unavailable, unexpected design issue, and loss or delay of data.
2. Clinical content: subcategories incorrect/inappropriate reference information, missing content, erroneous content, incorrect/inappropriate charting templates, erroneous content, inconsistent content.
3. People: System configuration issues, human factors, failure to carry out duty, inattention, staff qualifications-inadequacies.
4. Workflow and communication: Mismatch between workflow and HIT, communication failure, suboptimal support of teamwork.
5. Human-computer interface: Data display errors, data entry errors.
6. Internal organizational features: Policy in conflict with workflow, absence of protocol/standard process.

Third, Saleem and colleagues (2016) identified elements of an EHR for the purpose of recommending design principles that are more actionable than usability heuristics. These elements are: progress notes, problem list, consults, clinical reminders, clinical decision support, medication list, medication alerts, and medication reconciliation.

Fourth, we and colleagues, for the National Institute of Standards and Technology (NISTIR 7804), categorized root causes of use errors with implemented EHRs based upon reports of

patient safety issues across many hospitals and EHRs: Patient identification error, Mode error, Data accuracy error, Data availability error, Interpretation error, Recall error, Feedback error, and Data integrity error. Reported issues were recommended to be prioritized based upon the factors of 1) Severity: Magnitude of potential harm, 2) Frequency: Probability of harm occurring, 3) Detectability: Ease of recognizing use error that could lead to potential safety issues, 4) Complexity: Presence of factors that increase patient complexity for special patient populations, such as pediatric patients, patients with co-morbidities for which the risk of harm is higher, or patients with compromised immune systems.

Finally, we categorized EHR-related calls to the help desk during the first year of an EHR implementation across a multi-hospital system. Of the calls a small minority were safety-related, and there were no issues leading directly to patient harm in these reports. The categories used for this analysis (after excluding calls that were transferred to others, follow-ups on prior calls, hang-ups, ambiguous entries, and test calls to the help desk):

METHODS

De-identified reports of patient safety issues were shared anonymously via share4safety@gmail.com and personal communications with the facilitators or attendees by conference and non-conference attendees before and during a 90-minute session at the Human Factors in Healthcare International Symposium on March 8, 2017. One example of a reported patient safety issue was provided to the group which had been submitted in advance: "EHR hides all pre-op meds once patient is in recover. Patients can get over-dosed. Pre-op med form is buried in another format that is accessible by several mouse clicks which most people did not know about. Med list in post-op on patient's main page looks complete (but is not)."

Each attendee shared with a partner five concerns and identified the top concern from those shared in their two-person team. Then every team shared with the larger group these issues, which were written by a facilitator onto sticky paper and placed on the walls (see Figure 1).

Next, the issues were grouped using pre-defined categories and new categories were identified. Real-time electronic notes were taken by a human factors professional and pictures were taken of the post-it notes and posted notes. At the completion of the session, each participant voted for the highest priority cluster and/or individual patient safety issue using stickers.

PRIORITIZED CLUSTERS OF ISSUES

The following clusters were generated and prioritized. Each category was created in advance and placed on their own sticky sheet with a couple initial reports. Additional related issues were added to the sheets and in some cases additional categories were created and placed on their own sheet or half sheet in order to distinguish important elements. The numbers in brackets indicate the number of stickers placed on the category, where a higher number indicates a higher priority.

1. Ordering is complex and particularly challenging when transitioning locations (Priority = 6):
 - Partial dose 'transfer inpatient to outpatient' can end up having 8× dose if a 2X/day medication is given as a quarter tablet in the inpatient setting, but changed to a full tablet in the outpatient setting (thereby making it 8× the dose) - the dose has changed on the user without warning and the medication is in a list of all medications, so can be missed when reviewing
 - Comments field hidden – need to click on it and it is not clear which ones are populated without clicking, or it doesn't print. For the medication prescription, nurses cannot view the comment written by a physician until after the pharmacist has verified the order.
 - Taper dose is often a problem, first dose now as well is a problem
 - Declutter the screens of not given medications and then you never know it was not given – print a missed medications report in order to know, which might happen. If somebody orders a medication, it only shows for a minute. Only catch with missed medication report, which is a clunky design.
 - Vaccination order changes can be difficult to make, and often are required by be made by a physician. When a patient is adopted from another country, it can be important to use a different schedule in order to catch up.
 - When the patient changes location, it can delay orders (e.g., recovery -> ward)
 - "Delayed" from past hospital unit, in that you need to stop all previous IV orders in order to do new IV orders
 - 3 different versions of how you order a medication and only learn to pick the one that gets through the billing system
 - In the Emergency Department, you know you want to order a cardiac medication. Evidence-Based Practice bundle cluster order for a stroke victim. Same one embedded so doesn't check you when you order it. Have clerk enter it.
 - Pediatric dose round-up of the third digit after a decimal can lead to morbidity. Solution is to order small doses for pediatric patients using a paper-based system.
2. Cannot do a task due to access issue/workflow
 - Must be in an encounter
 - Must be assigned to doctor
 - Must document but no access because

- Another user must close prior encounter
 - Must use addendums after a note is signed
- Resident access instead of attending physician access
- Must wait until patient arrives (might mean arrival in Emergency Department or insurance in system)
- 3. Wrong/inflexible user profile in the EHR or hospital
 - Right level of physician needed on the first day
 - Residents first Monday on rotation (inevitable to have issue) -
> Solution is to have “same as ... “ (e.g., “make it like”)
 - Two roles are used on different days
 - PCA as full-time employee and RN student
 - Attending/Fellow (e.g., pediatric attending that has fellowship where student couldn’t access EHR stuff the first day because system viewed as fellow and not attending)
- 4. Patient identifier issues (Priority = 3)
 - Triplets can have files auto-merged if the same sex with the same birthday with the same last name in the same location and only one digit different on the social security number, leading to permanently lost data
 - Womb surgery
 - “save as ...“ mistake when creating a patient chart for the first time by a clerk overwrites the first patient’s chart with the new patient’s data
 - 8–10 patients in the hospital where S1111 is used to identify a patient
 - Using a complete social security identity number or other longer identity number would solve the problem
 - Issues where the wrong patient information is accessed due to underlying “first instance”/“broken links” auto-pull, leading to the wrong x-ray image being shown in a patient’s chart when more than one patient record is open
 - When the gender is wrong on a patient’s chart, some tests cannot be ordered
- 5. EHR down (Priority = 2)
 - Use paper/fax/etc. when EHR is unavailable, and fax can be difficult to replace quickly if it breaks
 - Specialists have no access off-site, but are often still expected to do surgeries without the ability to access information in advance

6. Discharge
 - Long list of discharge instructions (patient discharge instructions and packets) – where does the information go (who gets which instructions (where, who, how?))
 - Early printing for discharge problem where information missing when the hospital decides that a pharmacist needs to verify medication information in comments written by physicians before allowing nurse to print it
7. Navigation challenges (Priority = 4)
 - Hard to find information because in too many places (finding data/ searching)
8. Lack of training/education
 - Change log – every couple weeks they do changes (upgrades/updates/ changes to default settings) and people get fatigued because everything is different
9. Hybrid electronic-paper systems
 - Order TPN-format differences where multiple neonate patients had the potential to be adversely affected when a subset of patients switched up when manually entered things from top-to-bottom (“master recipe” with calculation error for 4 months)
10. Medication reconciliation (Priority = 13)
 - Cumulative dose effects
 - Medications with similar effects are not always listed in the same place so don’t get cumulative effect of drugs – due to mode and where (input-output) (e.g., might not realize getting oral and IV meds at the same)
 - Issue of saliency of different medications for providers
11. Documentation time (Priority = 2)
 - Amount of time spent charting is extensive for physicians and nurses
 - Change in interaction with patient due to charting for physicians and nurses
12. Overreliance on EHR systems
 - Need for reliability of the system
 - Need to not blindly click -> How to engage physicians at different points in the system without overburdening them more
 - Healthy skepticism is needed for users about the level of maturity of EHRs

13. Interoperability (Priority = 2)

- System to system interoperability can be one-way and thus confusing. Better not to have any information from other systems than to have incomplete lists that look complete, such as by combining medications from multiple systems.
- Allergies can be missed because of issue in translating between records lists across systems

In addition, there were individual concerns written on post-it notes, which were not discussed as a group because each team of two only shared their top concern. These comments were:

- Inability to format/personalize (text, color, font size) which would be fine if it were good design ...
- Many order sets/documents/forms cannot be organized in ways other than alphabetically and you can't free text search
- There is a very small team of Information Technology specialists to code/configure – leading to 16,000 hours backlog of change requests
- We cannot add visualization (e.g., trend data) into patient records (especially to aggregate)
- Nursing records as paper based and then scanned into EHR – cannot search those documents
- Erroneous data inputs (e.g., nurse wants to type 30 for Body Mass Index but types in 300 and no auto-correct or pop-up)
- Values are not required which leads to important missing data
- Location of computer system – tech/nurses may have to share only a few computers; Records may not be updated in a timely way and workers may have to rely on papers or memory recall when a computer is available
- Poor ergonomics of computer workstation due to design or worker's lack of training on adjustability of equipment, desk, chair, etc.
- Nurses unable to quickly identify in EHR which individual provider is the responsible party for patient in hospital/inpatient setting – who to contact if concern?
- Patient with complex visit -> Pre-op, anesthesia, office visit, surgery: EHR requires different encounters, orders placed for tests/studies at each encounter – issue: multiple providers, multiple documents, multiple orders
- Medication reconciliation involves multiple screens – medications prescribed outside the network are only seen if click through link to new screens – issue: risk for med error

- Interdisciplinary documentation and visibility of documentation is limited and must be completed in multiple screens with different report
- Phases of care require multiple points of optimization and causes confusion with providers and nurses
- Conversation during intake was turned into diagnosis which was not done by physician
- Not able to access them and talk to patient in most rooms causes pain
- Access to EHR puts nurse in bad ergonomic posture
- When cancelling e-prescription orders, unclear if orders are merely removed from documentation or actually cancelled at pharmacy
- Data overload – clinician notes filled with process of care documentation that hides clinically pertinent data; search capability weak, compromised by sheer volume; template and copy/paste
- Patient ID focus is on ID at bedside – no ID on EHR; name, block 1% of screen real estate; thus software that posts photo was removed
- EHR can launch non-modal window for different patient and provider gets confused as to which patient is being acted on.

DISCUSSION

In summary, the following categories of patient safety issues during EHR implementations and upgrades were identified to be a high priority for more than one individual (listed from highest to lowest priority):

- Medication reconciliation
- Ordering is complex and particularly challenging when transitioning locations
- Navigation challenges
- Patient identifier issues
- EHR down
- Time spent during documentation
- Interoperability

These insights are similar to those, which have been found by:

- National Institute of Standards and Technology workshop session titled “Usability of Medication Reconciliation” on September 7, 2016 (https://www.nist.gov/sites/default/files/documents/2016/09/01/nist_workshop_agenda_8_16_16.pdf)
- National Institute of Standards and Technology workshop session titled “Nursing: Next Steps in Risk Prevention and Mitigation” on September 7, 2016

- An analysis of 889 medication-error reports which listed health information technology as a factor contributing to the events submitted to the Pennsylvania Patient Safety Authority over a six month period. Medication orders using Computerized Provider Order Entry, verification using pharmacy systems, and administration with electronic Medication Administration Records were the most frequently reported tasks using technologies.

The insights generated from this session have potential implications for improving patient safety. The prioritized clusters highlight that improving the design and implementation of EHRs, as well as the ongoing upgrades for EHRs, is important for medication reconciliation, ordering clinical care processes across locations and transitions and navigating the EHR to locate information pertinent to patient care. Ensuring that the correct patient's chart is used when providing care and that EHR downtime is minimized is important. Significant concerns remain regarding the time to perform documentation even after systems have been optimized as well as whether or not to trust information that has been pulled from interoperable systems, and whether or not the available information represents a complete set due to interoperability challenges.

Multiple conference attendees reported that they planned to use a similar methodology within their own hospital system to validate whether these clusters of issues were relevant for their own settings. Thus, replicating the methodology for an individual hospital as well as using these insights may inform reporting systems and quality improvement initiatives with health information technology where choices made by hospitals during implementation and upgrades as well as design flaws with EHR technology both contribute and interact to produce patient safety issues.

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Figure 1.
Example of facilitator notes

TABLE 1

Classification of Human-factors Themes

HUMAN-FACTORS THEMES
Automation Surprise
Back-up System Failure
Standards/Consistency
Error Prevention & Recovery
Program Inflexibility
Multiple Users Not Accommodated
Violation of User Expectations
Visibility
Workaround
Workflow
Systems Communication
* Coding Error

* Theme not necessarily related to human factors

TABLE 2

Classification of Risk Types

RISK TYPE
Identification Risks
Medication/Dosage Risks
Communication Risks
Alerts do not reach provider
Clinical order information not received by the service
Lab data not received by provider
Clinical Data Risks
Clinical data not available to provider
(Permanent) loss of clinical data
Misinterpretation of clinical data
Corruption of clinical data
Incorrect clinical data
Incorrect triggering of time sensitive events for clinical data
Regulatory Risk/Issue

TABLE 3

Classification categories and descriptions for calls to the help desk

Category	Description
Workflow	Workflow, smart text, inbasket
Security	Modify access, password, install
Order	Modify selection, schedule, dose
Hardware	Change printer location, reprint, WOW/PC, bar code
Flaw	Error, unexpected action, missing function, inaccurate data, slow
Transfer	Unable to transfer, check-in, discharge patient
Scheduling	Non-routine request, wrong physician/patient
Training	Support users in using software
Integration	Issues from integration with software