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A text mining analysis of medication quality related event reports from community pharmacies

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ABSTRACT

Background: Medication errors are estimated to cost $42 billion in annual global treatment costs. Pharmacy-based Patient Safety Organizations (PSO) are tasked with collecting and analyzing incidents, near misses, and unsafe condition reports as one way of engaging pharmacies in quality improvement efforts. Collectively, these reports are referred to as quality related events (QREs). Large-scale analysis of typed narratives from QRE reports across organizations has been a missing component of quality improvement programs.

Objective: To identify topics within the components of a proposed medication safety event framework contained in the free-text narrative of QRE reports.

Methods: A retrospective, observational analysis of data from a PSOs voluntary reporting system, from January 1, 2011 to December 31, 2014. The dataset contained structured and unstructured data elements. A structural topic model extracted themes from the free-text narrative component of the report. These topics were assigned a human label and mapped onto constructs of the medication safety event framework.

Results: A total of 531,555 QREs were analyzed from 1660 pharmacies. 90.6% were near miss and unsafe condition reports. There were 40 topics generated. There were 29 topics identified as QRE types, 3 were identified as contributing factors, and 5 were related to signals/alerts that an incident or near miss had occurred. One topic each was identified as a recovery step and a quality improvement strategy. One topic was not assigned a human label. Examples of topics labeled included incorrect tapering directions, needing to double-check work, and attention-related contributing factor.

Conclusions: The free-text narrative provided novel information compared to the structured fields of the reports. Topics were mapped onto a proposed medication safety event framework to advance knowledge of medication QREs and identify ways to improve medication safety in community pharmacy. Future work may focus on communicating these topics to the pharmacies to improve medication safety efforts.

Introduction

Medication errors that result in harm are a significant burden to the United States healthcare system and around the world. Estimates state that up to $42 billion are spent annually in the world to care for patients as a result of these medication errors.[1] These errors take place in all sectors of the health care industry.[2–6] A spotlight was shown on medication errors following the Institute of Medicine's (IOM), *To Err is Human* Report.[7] This seminal report served as a call to action to help make healthcare safer.

One of the key recommendations made by the IOM report was to establish voluntary reporting systems as a learning strategy to improve patient safety.[7] Reporting systems are a mechanism for healthcare providers to document quality-related events (QREs). In the US healthcare system, there have been systematic barriers that worked against organizations establishing reporting programs and front-line practitioners reporting QREs. These barriers included the absence of legal protections for the confidentiality of information collected for the purposes of learning, sharing of that data for learning and using the data to conduct quality improvement and patient safety activities. Historically, this led to under-reporting, missed opportunities to learn from mistakes, and failure to take actions that would reduce future risk

Abbreviation: PSO, patient safety organization; QRE, quality related event

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and improve safety.[7] Community pharmacies (independent, regional, and chain) were particularly vulnerable to the potential for litigation as these entities were not included in the peer review protections available to the medical staff in hospitals. Even within the statutory protections afforded by medical staff peer review statutes, the protections varied widely among states in how these protections applied and the strength of the protections.[7] Recommendation 6.1 of the IOM report noted that Congress should pass (federal) legislation to extend peer review protections to data related to patient safety and quality improvement that are collected and analyzed by health care organizations for internal use or shared with others solely for purposes of improving safety and quality[7,7].

Progress towards this recommendation was spurred by the passing of the federal Patient Safety Act of 2005 which provided legal protections to Patient Safety Organizations (PSOs) and members of PSOs that collect and analyze quality improvement data and QREs.[8] The Agency for Healthcare Research and Quality (AHRQ) is responsible for administrating the Patient Safety Act and the Rules that regulate PSOs. PSOs are entities that attest to having expertise in identifying the causes of, and interventions to reduce the risk of, threats to the quality and safety of patient care. The term "safety" refers to reducing risk from harm and injury, while the term "quality" suggests striving for excellence and value. There are eight patient safety activities that are carried out by, or on behalf of a PSO, or a health care provider:

1. Efforts to improve patient safety and the quality of health care delivery
2. The collection and analysis of patient safety work product (PSWP)
3. The development and dissemination of information regarding patient safety, such as recommendations, protocols, or information regarding best practices
4. The utilization of PSWP for the purposes of encouraging a culture of safety as well as providing feedback and assistance to effectively minimize patient risk
5. The maintenance of procedures to preserve confidentiality with respect to PSWP
6. The provision of appropriate security measures with respect to PSWP
7. The utilization of qualified staff
8. Activities related to the operation of a patient safety evaluation system and to the provision of feedback to participants in a patient safety evaluation system

The work of a PSO is not directed by AHRQ. PSOs essentially serve as contractors to providers and a PSO's activities for a provider are usually determined by the Patient Safety Act contract entered into by the parties. The primary activity of a PSO must be to conduct activities to improve patient safety and health care quality. Since the passage of this legislation, as of July 2018, there are 83 PSOs offering voluntary reporting systems across the USA and its Territories.[9] However, in follow-up reports of *To Err is Human*, experts have cited that a slow pace of improvement could be attributed to, in part, insufficient learning from errors and QRE reports.[10,11] The data captured on an error reporting form include both categorical and narrative data. Reporters, usually front line practitioners, will submit a report by checking boxes to describe the type of error, where the error occurred in the workflow, where the error was detected, the level of harm (if any), and related characteristics. Some reporting forms allow the reporter to enter narrative description of the error. Narrative comments by the pharmacy manager, safety coordinator and peer reviewer may be recorded as the front-line report undergoes further investigation and verification of the facts. A literature review of published data on medication errors from international community pharmacies and hospitals in the UK, US, Australia, Spain and Brazil found a primary focus on classifying QREs into broad categorical groups.[5] These categorical data, while useful for building a searchable database of QREs and performing descriptive analyses of prevalence, do little to help community pharmacies to address the underlying causes of medication errors. One component of medication QRE reports that has not been analyzed extensively in the literature is the free-text narrative.

The free-text narrative provides a written account of the QRE that occurred. Large-scale analysis of free-text narratives is difficult to carry out many thousands of reports efficiently. The hypothesis is that the free-text narrative provides additional insight into QREs that are occurring in community pharmacy and enable actionable feedback to help pharmacy staff to prevent these QREs in the future. This objective of this study was to identify topics within the components of a proposed medication safety framework from the free-text narratives of QRE reports.

Methods

A retrospective, observational study was conducted using QRE reports voluntarily submitted to a single AHRQ-listed PSO from January 1, 2011 to December 31, 2014. Pharmacies represented a cohort of 1660 pharmacies in the United States and Puerto Rico. Previously, 54 pharmacies were removed from the dataset as their QRE reports were documented in Spanish. All pharmacies reported their QREs electronically into a secure cloud-based multi-tenant application, using a standardized data collection format. The pharmacies in this sample are encouraged by this PSO to report, analyze, and learn from QREs and have a goal of proactively making safety and quality improvements that will prevent future harm. A proposed medication safety event framework (Fig. 1) served as the basis for categorizing the output of the analysis using a deductive approach. This framework builds on previous models of healthcare quality and safety, including the Systems Engineering Initiative for Patient Safety (SEIPS) Model and the Threat and Error Model.[12,13] The framework depicts that prescriptions have certain

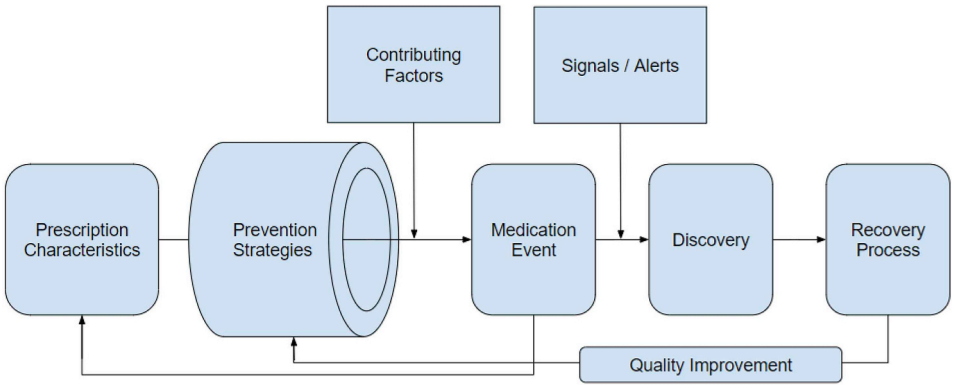

Fig. 1. Proposed medication safety event conceptual framework.

characteristics (e.g., new/refill, electronic/phone) and the pharmacy has existing prevention strategies in place. These prevention strategies can be likened to Reason's Swiss Cheese Model, in that, despite our efforts to prevent errors, holes in the system mean that errors still occur.[14] Contributing factors for each error type depends on the characteristics of the prescription and influences the type of error. When an error is discovered, a detection mechanism (i.e., signal/alert) is associated with the discovery. Upon discovery, staff attempt to resolve the event through a recovery process and identify quality improvement efforts to prevent the situation from occurring again.

Framework

Data source

Data were obtained from a federally-listed PSO that specializes in supporting community pharmacies in the USA and Puerto Rico. The data used for this research were extracted from the PSO database by PSO personnel, who rendered the data non-identifiable, as defined by Section 3.212 of the PSO rule, in order to allow the data to be disclosed to and used for secondary analyses by non-PSO entities. The dataset contained structured fields (i.e., categorical and numeric variables) as well as unstructured fields (i.e., free-text narrative). Examples of structured QRE types include incorrect drug, incorrect directions, and failure in pharmacist drug review. Examples of contributing factor types included human factors (e.g., slips/calculation errors), training or supervision, and work environment. These structured data were self-selected from a drop-down menu in the reporting platform. This paper focuses on the analysis of the unstructured data. The variable of focus in the analysis was the free-text narrative written by pharmacy staff when a QRE was reported.

Data cleaning

A corpus (i.e., a collection of text characters across multiple entries) was created. Reports were excluded from the dataset if they contained one or no character strings and if the content of the free-text narrative was written in a language other than English. Data were first cleaned using standard text mining and topic modeling procedures.[15,16] Stop words were removed from the data which include terms like “I”, “of”, and “a.” These terms provide non-discriminating information and decrease model efficiency. Punctuation was removed and all terms were converted to lower-case. Terms that appeared less than 10 times in the corpus were removed. A pharmacy ontology was created based on words commonly contained in the corpus (e.g., instances of “drug” and “med” were replaced with “medication”). Sig codes were standardized. Spell corrections were also performed and accounted for the use of 180 pharmacy specific terms not found in a standard English dictionary (e.g., medication device names). The final data were determined to contain 98.3% correctly spelled terms and visual inspection of the remaining words showed infrequent use or no inherent meaning. All data cleaning and analysis procedures were performed using the statistical software language R, version 3.3.0.[17]

Data analysis

Data were analyzed using a structural topic model, a type of natural language processing machine learning algorithm that sort terms in a corpus based on the probabilities with which they appear together across observations in the dataset.[15] This model uses the structured data contained alongside text variables to inform these probabilities and was developed specifically for this purpose in social scientists. Structured variables from the dataset that were used to determine the topics included new/refill prescription, prescription type, QRE type, and contributing factors. Topic models can be thought of as automated content analysis and are particularly useful when the number of text observations is prohibitively large to perform manual analysis.

A topic model is generated by selecting a given number of topics to be produced. Consistent with Roberts et al., the decision on the number of topics to include was determined based on a combination of diagnostic criteria for different numbers of topics as well as human inspection of the model outputs.[15] The output of the structural topic model includes the topic content (i.e., the topic-word distributions) and the topic prevalence (i.e., the proportion of the narrative contained by a topic). Topics were assigned human labels based on the highest-ranking 6 words for each topic as well as through inspection of the highest-ranking narratives that made up each topic. Topics were then classified into one of the components of the proposed medication error framework. Topic assignments were reviewed independently by two investigators and then together to reach consensus on the naming of the human labels.

Results

There were 531,555 reports included in the analysis from 1660 pharmacies. 90.6% of the reports were classified as near misses (i.e., potential incidents or events that never reached the patient) or unsafe conditions. The median number of words included in each narrative was 4 (Interquartile range = 5). The most commonly mentioned terms were “wrong”, “prescription”, “incorrect”, “entered”, and “patient”. Forty topics were generated from the structural topic model. Of these, 39 were assigned human labels. There were 29 topics identified as QRE types, 3 topics identified as contributing factors, 5 topics as a signal/alert to the discovery, and 1 topic as a recovery step, and 1 topic as a quality improvement strategy. Table 1 provides a breakdown of the topic labels by framework construct as well as the top words for each topic and representative narratives from the data.

The most common topic identified from the structural topic model was the contributing factor, “attention-related.” Words attributed to this topic represented approximately 9.5% of all the report narrative content. The second most prevalent topic was “incorrect days supply” occurring at just over 6.4% of all the report narrative content. The least prevalent topic, “action taken on discovery” represented approximately 0.2% of the report narrative content. Some topics were identified as being the same as an event type that could be found in the structured field. For example, the use of a safety cap instead of an easy cap was found to represent approximately 1.3% of all the content of the event narratives. This contrasts with the structured field “Incorrect Safety Cap” which was selected as the event type for 3.2% of all reports. Other topics of interest, include “needing to double check” as a quality improvement strategy which was accounted for 1.7% of all report narrative content and the “patient receiving the wrong prescription bag” which was estimated at 4.0% of all the narrative content.

Discussion

To the best of the authors knowledge, this is the first time a topic model analysis has been applied to medication quality-related events. The majority of the topics produced from the structural topic model represented characteristics of the reports that were not contained in the structured fields. These pieces of information were primarily found in the form of event types, contributing factors, and signals/alerts that an event occurred. Additionally, the structural topic model identified an instance of the recovery process and a quality improvement strategy. These unique characteristics were either not identified by the structured fields (e.g., prescriptions processed for a family member) or contained more detailed information than what was available in a structured field (e.g., incorrect directions in structured data compared to incorrect spelling, dosing frequency, tapering directions, and eye-specific directions in topic model). The following sections describe a sample of topics found from the framework components and discuss the implications for medication safety.

Table 1
Topics categorized into the medication safety event framework constructs.

Human Label	Narrative Examples from Data	Topic Content
Medication Event Types		
Input wrong dosage form	Input wrong drug form in directions-input for "*tablet*"; should be "*capsule*"	form, input, sustain, dose, given, prescript
Incorrect physician chosen	incorrect physician chosen the physician last_name the physician chosen is physician last_name and his address phone are incorrect when i did a lifeline search physician is in [state] physician a is in [city name]	physician, address, chosen, search, wrote, input
Running prescription for family member	Escripts for father, entered for son, son's insurance required PA when working with PA discoved that 2 rx were filled for son, father	sent, ran, family_memb, process, last_nam, electron
Incomplete/Incorrect prescription information entered	entered "*decrease by*" instead of "*increase by*"	enter, incomplet, input, incorrect, prescript, technician
Omitting quantities (refills, volume) on prescription	three evening as_needed missing t three	miss, three, five, info, omit, amount
Incorrect days supply	Incorrect days supply-entered 35 days; should be 28 days	incorrect, day, enter, input, one_eighti, calcul
Incorrect number of pills in bubblepacks	cassette filled with 1 capsule per slot; should have been 2 capsules per slot	instead, capsul, pack, medbox, slot, say
Incorrect number of refills	typed number of refill for quantity and missed refills, very careless	refil, quantiti, number, inform, packag, info
Immediate Release vs. Extended Release	Metformin 500 mg vs metformin er 500 mg	strength_mg, releas, extend, immedi, regular, metformin
Incorrect eye directions	eye drop typed as 1 drop in each eye should have been 1 drop in right eye	type, prescrib, drop, eye, ointment, right
Dispense as written prescriptions	pharmacist noted during order verify dispense as written one stated	dispens, written, order, verifi, note, brand
Safety cap instead of Easy cap	A safety cap was used when there was a request for no safety cap to be used.	use, safety_cap, request, vial, ez_cap, open
Typing directions incorrectly	Incorrect directions-had random inject direction in the middle of Tablet directions.	direct, typist, input, incorrect, enter, technician
Omitting required prescription elements	Patient's date of birth not on Rx itself-on attached page; document DOB on hardcopy	didnt, differ, birthdat, hardcopi, updat, imag
Incorrect number of pills in bubblepacks	Bubbles should have been 2 tabs per bubble and was bubbles as 1 tab.	tablet, cap, bubbl, safeti, suppos, extra
Incorrect dosing frequency	entwered every 4–6 h should have been every four hours	everi, four, as_need, six, twelv, time
Wrong product chosen in computer	data entry person choose more expensive product, not understanding the difference between the products	entri, data, comput, product, also, person
Grabbing wrong NDC off shelf	sound alike drugs. on same drug shelf. wrong drug pulled	drug, ndc, pull, pick, shelf, dosag
Patient received wrong prescription bag	pt was given another pt's medications by mistake so pt brought back other pt's medications in exchange for her medication	patient, receiv, back, profil, bag, given
Incorrectly spelling on directions	wrong sig spelling	sig, spell, technician, hold, product, due
Incorrect number of boxes dispensed	Wrote for 3 boxes per month of Ventolin inhaler; only gave 1	one, two, box, wrote, month, inhal
Incorrect origin code	Entered incorrect origin code of 2Phone; should be 4Fax. Not esigned. Code still entered as 2Phone as of this date.	date, written, origin, code, eleven, fax
Labeling the wrong prescription bottle	the levothyroxine pills were put in the sertraline bottle and vice versa - switched the pills and put them in the correct bottle	label, bottl, put, place, mix, basket
Incorrect tapering directions	Directions: 3qd x3, 2qd x2, 1qd ×1 labeled: 3qd x3, 2qd x2, 1qd ×10 days pt. took correctly	correct, twicedaili, oncedaili, threetimesdaili, suppos, first_nam
Incorrect drug selected	Wrong drug strength was selected	Select, pay, wrong, drug, incorrect, chosen
Incorrect liquid volume	Each syring only has 0.8 ml – billed for 1 ml per syring	strength_ml, ten, seven, syring, size, teaspoon
Misfilling brand instead of generic (vice-versa)	should have been for cream, entered as ointment. e-scripted as generic. the cream does not come in generic	generic, brand, cream, plain, strip, rather
Filling incorrect quantity	should have filled 90. Only filled 30	fill, thirti, count, sixti, nineti, gave
Incorrect auxiliary labels	no control sticker or fda sticker on bottle	prescript, sticker, due, miss, correct, enter
Contributing Factors		
Not updating new prescription after renewing old	Copied forward old –redacted- without changing to new –redacted- on new rx	left, new, old, prescriber, without, renew
Forgetting to read carefully	Forgot to include take prn anxiety didn't read notes on rx	take, daili, forgot, read, by_mouth, bedtim
Attention-related	not paying attention when selecting LASA drug,strengths, & forms	wrong, attent, product, chosen, technician, input
Signal/Alert		
Catching technician during review	sliding scale was for novolin r not novolin thirty error caught during initial pharmacist review	technician, error, caught, fix, review, initi
Clinic called about discovery	patient had new prescription called in from the office called office because of patient conern about change in dosage was not to change	call, chang, said, offic, contact, instruct
Adjudication discovery	Billed insurance for incorrect days supply	suppli, insur, calcul,bill, fifteen,, thirti
Pharmacist discovered	Pharmacist discovered error while trying to reconcile C2 log for oxycodone/apap.	pharmacist, discov, name, mistak, upon, similar
Patient noticed something	pt. noticed pill looked different and called back and told to bring back	notic, chose, look, made, told, realiz
Recovery Process		
Action taken on discovery	Error discovered 3 days after filling. No action taken.	just, taken, actual, action, say, state
Quality Improvement		
Needing to Double Check	Refills were entered incorrectly. Need to make sure that we are entering everything in correctly. Need ot make sure that we are double chekcing that hard copy prescrption to make sure that all informationt aht is being entered matches	check, need, final, doubl, found, make
Unlabeled		
[unlabeled]	Dr sent over rxs for the Humria 40 mg starter dose and maintenance dose. The maintenance dose was entered in [dispensing software], PV1ed, and shippedand the starter dose was never entered into [dispensing software].	prescript, dose, requir, eot, due, pill

Contributing factors

The contributing factor identified as 'attentional-related' was found to be the most prevalent of the content found in the topic model output and accounted for almost 9% of the report narratives. Study of human cognition found that Errors attributed to attention are among the most common reasons errors occurand are the result of slips (i.e., attention-related) and lapses (i.e., memory-related) in behavior.[18–21] Interruptions have been well documented as impacting attention and concentration in task performance by pharmacists.[22,23] Previous researchers conducting a survey of medical interns found that extended-hour shifts resulted in significantly more attentional failures.[24] In general, it is not uncommon for pharmacists to report working shifts in excess of 12 h with few to no rest breaks.[25] Combining long shifts with high-paced and high workload work environments[26,27] fatigue induced attentional failures is an important area of research to improve medication safety.

A second contributing factor identified by the topic model is that of 'renewing old prescriptions into new ones.' When a patient has a prescription for the same medication that they have had previously, pharmacy staff often copy the old prescription contents over into a new prescription using a feature common in pharmacy dispensing software. This decreases the need for pharmacy staff to retype all of the prescription information into the software. This topic suggests, however, that this software design feature introduces a patient safety concern. Pharmacy staff using this method of entering a new prescription can miss changes on a new prescription. Research into the effect of removing or improving this feature from dispensing software is warranted.

QRE types

The mix up of immediate and extended release products has previously been identified in the literature and presents a potentially important medication safety concern.[5] The medication safety concern can arise when these immediate and extended release formulations are mixed up and dispensed incorrectly, as identified by the topic model. Immediate and extended release formulations are generally considered look-a-like/sound-a-like medications (LASA).

LASA products have been well documented in the literature and include those with drug names that are similar to one another (e.g., hydralazine and hydroxyzine).[5,28,29] They have been identified as having a greater risk of being mistakenly dispensed in place of the originally prescribed product. LASA products have even been a focus of the Food and Drug Administration (FDA).[30] Interestingly, not included in these lists are immediate and extended release formulations of products. Based on the findings from this analysis, these products should be on lists of known look-a-like/sound-a-like medications. Mixing up these formulations can result in under-treatment of disease or increases in the risk of adverse drug events.

Pharmacies filling prescriptions for multiple family members may also contribute to medication QREs. The topic model identified a topic as 'processing prescriptions for the wrong family member.' The process by which pharmacy staff entering a prescription into the dispensing software may help explain why this occurs. Pharmacy staff traditionally search using the first few letters of a patient's first and last name. In turn, this produces a list of potential patients that meet the criteria. Staff select the patient using the information found on this screen (e.g., first and last name, address, and telephone number). Without using another identifier for family members, some of these criteria will match, decreasing the ability to detect a discrepancy when selecting the patient's profile. Additionally, if the patient has never filled a prescription, the pharmacy staff may inadvertently choose someone who was already in the computer system if the search criteria partially matched what was entered. In other cases, a patient may bring in prescriptions for more than one family member at the same time. Pharmacy staff entering the prescription may not detect the different names and fill all the prescriptions for the same patient.

One strategy that could decrease the prevalence of this QRE type would be to use the patient date of birth as the initial search criteria instead of the patient's first and last name. While it's not published in the literature as an effective strategy, using the date of birth as the primary search criteria and then matching first and last name makes sense as one way to help minimize the occurrence of this happening. This strategy may act as a forcing function by minimizing the presence of similar first and last names and encourage 2-step verification to then match the date of birth with the patient name. More research should determine best practices for preventing this QRE type.

Error discovery signal/alert topics

Five topics were identified as signals and alerts for the detection of medication QREs. This component of the medication dispensing process is seldom mentioned in the literature. Barcode technology is the primary alert that has been documented in the literature with the majority of evidence for the benefits of barcode technology having occurred in nursing.[31,32] Somewhat surprisingly, the structural topic model did not identify barcoding technology as a topic in the report narratives. This technology is a core component in pharmacies today and it was expected that this technology would be identified as an alert to the incorrect medication at the prescription filling stage of the dispensing process.

One alert identified, related to the detection of an error upstream in the dispensing process when the pharmacist performed a check of others' work. These occurred in two primary phases. Some pharmacy dispensing software platforms have a pre-verification step which involves a pharmacist review and approval of the content entered into the dispensing software after being transferred from the original prescription, but before the medication has been filled, counted, and labeled. This splits up the number of steps the pharmacist must complete at the final verification and allows for detection of an error prior to going through the work of counting and labeling the prescription vial. The pharmacist also performs a second check after the counting and labeling of the prescription, which also occurred as a detection of an error from a technician. This alert highlights the usefulness of a pharmacist double-checking the work done by others as a method to minimize errors that reach the patient. Previous research from the nursing literature demonstrates effectiveness of this double-checking strategy.[33,34]

A second alert identified by the structural topic model was the 'patient noticing something different about their medication.' For example, some patients rely on the shape, size, or color of a medication to distinguish between their medications.[35] When the size, shape, or color change, a patient may decide to communicate with the pharmacist about the change before taking the medication. Patients calling about something different with their prescription or receiving a prescription for something they were not expecting highlights the important role that patients play in ensuring their own safe use of medications. Patients act as their own safety monitors by questioning differences in their expectation and not assuming that the healthcare system has performed correctly. Patients should be encouraged to question these differences as this topic identifies because they can protect themselves from an imperfect, albeit improving, healthcare system. Pharmacists and technicians are likewise encouraged to listen carefully to patients that raise concerns about any differences in the medication they receive compared to what they expected to receive.

Quality improvement topic

One topic identified by the structural topic model is that of 'needing to double check' as a quality improvement strategy. The medication dispensing process in community pharmacy contains numerous checks and balances to help achieve the safe and correct dispensing of medication to patients. These types of checks and balances are found at different stages in the process and are common across health professions.[36,37]

Separate from the checks and balances at different stages of the dispensing workflow, this topic referred to the process of a self–checking procedure in the report narratives. For example, pharmacy staff mention needing to double check the directions they typed when inputting a prescription or double checking the NDC (national drug code) for a prescription stock bottle they just got off the shelf. This is in contrast to the published literature whereby double-checking is defined as one person independently checking the work of another. In community pharmacy practice, this happens with the majority of prescriptions dispensed. Based on the findings from previous literature, a large number of errors are detected by the process of double-checking another person's work. Asking pharmacy staff to double-check themselves further reinforces the risk of confirmation bias. After an error occurs, this self-check can inappropriately shift the blame to the individual who "failed". This is supported in a Joint Commission Report from 2015 that identified double-checking and self-checking as only moderately reliable strategies for preventing medication errors, through the perspective of human factors engineering.[38] As a result, the time and effort could be better spent focusing on the design of pharmacy work that addresses the cognitive limitations of humans. Examples from the Joint Commission Report include forcing functions that prevent incorrect actions, computerized automation, and human-machine redundancy (i.e., humans checking work along with technology performing a parallel check). Introduction of new forcing functions could minimize the reliance on double-checks and self-checks.[39]

Limitations

The data reported are voluntary and self-reported from pharmacy staff. As a result, these data do not represent every QRE that may have occurred in the pharmacy. The self-reported nature of the reports means that the narrative is based only on pharmacy staff perception of the event and it was not possible to breakdown by the type of reporter (e.g., pharmacist vs. technician). These reports are subjective in nature and the QREs reported have not been subjected to root cause analysis. As a result, caution should be taken when generalizing the findings or making assumptions about the nature of pharmacy practice and characteristics of QREs that are described in this paper. The data cannot be used to compare QRE rates nor the types of QRE among pharmacies. Data in this report cannot be used to make any inference about the degree of patient harm associated with the reports. Additionally, because topic models are a relatively new method of analysis there are no well-accepted methods for assessing topic quality. The authors relied upon their domain expertise and manual review of the narratives that scored highly on each topic to make decisions about the labeling of the topics. Also, the topics should not be interpreted as the 'true' number of topics contained by the data, rather, the goal was to maintain interpretability by minimizing broad themes (i.e., too few topics) and overlapping themes (i.e., too many topics). These kinds of determinations are not unlike traditional content or thematic analysis.

In addition, the use of the free-text narrative by pharmacy staff was varied. The length of the narrative was often short and did not provide a detailed account of the QRE. This could be, in part, due to the reporters having competing demands of patient care, prescription processing, and reporting of QREs while in the pharmacy as well as the vague language for what to report in the free-text narrative in the reporting platform (i.e., Pharmacy Notes: Short Description of Incident). Future improvements to the reporting platform may include more specific free-text questions so as to elucidate more nuanced data.

Conclusions

Constructs of the proposed medication safety event framework in community pharmacies were identified through a large-scale, automated content analysis of the free-text narratives of pharmacy QRE reports. Analysis of these data included contributing factors that led to medication QREs, the specific types of QREs that occur, how these QREs are discovered, and a pharmacy staff identified quality improvement intervention. Although a comparison was not reported here, the topics found by the natural language processing model were more detailed or novel aspects of a QRE compared to data found in the structured fields. Efforts to incorporate the free-text narrative themes into the quality improvement programs of community pharmacy may serve as a more effective approach to improve organizational learning and medication safety.

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Declaration of interest

TM is an employee of the organization that provided the data. JMK is a paid consultant of the organization that provided the data.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.sapharm.2018.09.013.

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