Developing a Taxonomy for Coding Ambulatory Medical Errors: A Report from the ASIPS Collaborative

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Abstract

Background: Multiple taxonomies are used to classify medical errors. Most are conceptually based with limited empirical evidence on their utility to characterize processes leading to errors. We analyzed the utility of the Dimensions of Medical Outcomes taxonomy to describe medical errors and their relationship to harm. **Methods**: Individuals in 34 primary care practices reported medical errors to a Patient Safety Reporting System. Based on the first 357 reports, we modified a multi-axial taxonomy to improve the description of primary care errors. We then applied 337 of 421 available taxonomy codes to 608 error reports. Analyses included basic frequencies, cross tabulations, and odds ratios to examine the ability of the taxonomy and its underlying constructs to describe patient safety events and their relationship to harm. **Results**: Four individual codes were associated with harm, including therapeutic intent of an activity, language barriers, and errors of judgment. Harm was also associated with 10 constructs within the taxonomy hierarchy and 8 derived constructs. These constructs included communication from another office, mistimed procedures, medication errors, and involvement of the treating clinician. Harm was not associated with incorrectly performed procedures or failure to perform procedures or general information flow within, into, or out of the office. **Discussion**: Approaches to classifying medical errors vary widely. While our highly detailed approach required a relatively large number of reports to be useful for examining individual codes, it allows the use of different analytical approaches to help uncover processes in primary care that lead to medical errors resulting in patient harm. **Conclusion**: Taxonomies developed to understand medical errors should be analyzed empirically, using quantitative and qualitative approaches to demonstrate their utility for describing medical errors, as well as the level of detail required for varying uses.

Introduction

There is no single internationally recognized taxonomy for coding ambulatory medical errors. Current taxonomies vary widely in scope and aim. Of the available taxonomies used to classify medical errors,[1–8] some include lists of descriptive words organized into several domains,[5] while others use hierarchies based on the developers' approach to understanding errors.[6–11] Furthermore, the

approach to codification varies widely among different groups studying medical errors. For instance, the New York Patient Occurrence and Tracking System (NYPORTS)[12] and early users of the American Academy of Family Physicians (AAFP)-Linnaeus Primary Care Patient Safety Taxonomy[9] primarily applied a single global code to an error report, while the Applied Strategies for Improving Patient Safety (ASIPS) and Medical Errors Reporting System (MERS) coding schemes label each event with multiple relevant codes.[2, 3, 10] The resulting description of medical errors may vary, based on the coding approach as well as the codification schema. Furthermore, most taxonomies are conceptually based and have not been evaluated to determine their utility in furthering the understanding of the processes involved in errors.

An important exception to the conceptually derived taxonomies is the AAFP-Linnaeus taxonomy developed by Dovey, et al.[7, 9] The AAFP-Linnaeus taxonomy uses an iterative, qualitative analysis of medical error reports to develop a hierarchical taxonomy that describes error processes in primary care. The qualitative approach identifies themes found in the available data, instead of imposing on the data concepts and constraints based on preconceived ideas. The AAFP-Linnaeus taxonomy is grouped into two major sections: process errors and knowledge/skills errors. The codes provide detailed descriptions of actual events and seem to be easy to use for anyone with clinical knowledge. However, potential issues with the current version include its inability to easily separate the event processes from the participants; the lack of information on who discovered the event; and the mixing of process and causation codes. The inability to clearly delineate causation may limit the ability of the AAFP-Linnaeus system to promote the development of interventions designed to improve care and decrease errors. Furthermore, it is unclear if the taxonomy can highlight similar process errors across different clinical activities or among the array of error processes within a given clinical area. The qualitative approach used to develop the AAFP-Linnaeus taxonomy has strengths and the themes and constructs identified need to be included as ambulatory patient safety taxonomies are further developed.

Other taxonomies, although primarily developed for inpatient use, have been applied in the ambulatory setting.[1, 5, 10] Given the major differences in the care processes between inpatient and outpatient settings, it is unclear whether descriptions of the breakdowns in care in one setting can be applied to another. Taxonomies designed to evaluate specific domains of errors, such as the National Coordinating Council for Medication Error Reporting and Prevention,[1] may apply across care settings, but are designed to specifically describe one aspect of the medical error universe. Moreover, not all error taxonomies[1, 2] have been made available for public scrutiny,[4, 5] slowing comparative work among and across coding systems and hindering continued advancement of the discipline.

For the ASIPS project, we adopted an existing conceptually based taxonomy, Dimensions of Medical Outcomes (DMO),[8] to codify medical error events because we believed that it offers a conceptual approach to codification that could help elucidate failures across seemingly disparate activities. The DMO taxonomy was originally developed to code malpractice claims and has been used by others

for 6 years. It is a multi-axial taxonomy designed to codify the universe of errors across care settings and disciplines. The purpose of this paper is threefold. First, we will briefly describe the development and modification of the DMO based on actual primary care patient safety events reported to ASIPS. Second, we will describe the use of the ASIPS DMO[3] to identify individual codes and patterns of codes within events that resulted in patient harm. Third, we will describe the ability of the ASIPS DMO to provide a multidimensional description of events that allows for easy grouping of error processes across various clinical activities or errors within specific clinical activity across various types of processes.

Methods

ASIPS is a multi-institutional demonstration project designed to collect and analyze data on medical errors that occur in primary care ambulatory practice. The ASIPS Patient Safety Reporting System (ASIPS PSRS) collects event reports that appear to materially affect care within the primary care office from two practice-based research networks: the Colorado Research Network (CaReNet) and the High Plains Research Network (HPRN). The participating practices are located throughout urban, suburban, rural, and frontier regions of Colorado, and represent more than 500 clinicians who see a diverse patient population in terms of age, race, ethnicity, socio-economic status and medical problems. The ASIPS protocol was approved by the Colorado Multiple Institutional Review Board (COMIRB) and the institutional review boards of practices not covered by COMIRB. The core of the ASIPS PSRS is a Web-based data collection and data management system, described in detail elsewhere.[13, 14]

We asked individuals to report "any event you don't wish to have happen again, that might represent a threat to patient safety." This broad definition allowed participants the freedom to interpret what is a safety event, and is similar to the error definition used in other primary care patient safety studies.[7, 9] We emphasized that this definition includes events associated with clinical judgment/knowledge; administrative or clinical procedures; and threats from near misses where no patient harm actually occurred. Given the paucity of literature on primary care ambulatory medical errors at the inception of this study, we were concerned that if we provided detailed descriptors of various error types it might limit the scope of events reported by our participants.[11]

ASIPS accepts confidential or anonymous reports by telephone hotline, secure Web site, or paper mail-in. All three modes use the same data collection forms.[13] For the majority of confidential reports, we schedule followup interviews to gather detailed information concerning the event. From the time we receive a report, we allow up to 10 days to contact the individual for an interview. If we elect not to pursue a particular event or if the followup has been completed, the contact information is deleted immediately. In all cases, contact information is automatically removed from the database within 10 days of submission.[14]

Taxonomy development

The DMO taxonomy includes five domains, four of which are used by ASIPS, and 38 axes, 10 of which are used by ASIPS. We coded the first 357 reports using version 01-0927 of the DMO taxonomy.[8] Our goal in using the DMO taxonomy was to provide a full description of each patient safety report, which includes coding all process steps, associated diagnoses, associated tests, associated medications, all participants, the outcome, and the person(s) who discovered the event. To be this inclusive, each event may be assigned multiple codes within each axis. Therefore, events can have a variable number of codes with a required minimum of 11 (the event type axis always requires 2 codes). The event description domain is arranged according to the process problems., e.g., delay in performing a procedure, a procedure not performed, or a procedure performed incorrectly. Detail of the clinical activity, e.g., lab process, imaging process, history taking, or physical examination, is then coded at a deeper level of the taxonomy (see Table 1). We modified the taxonomy based on the first 357 reports to better describe primary care errors. Both the original taxonomy and the ASIPS modified version are available for review.[3] The result is a hierarchical taxonomy that groups errors by process and clinical activity at the finest gradation, and allows for easy grouping by process across various types of clinical activities or by clinical activity across various types for processes.

The original 357 cases were recoded using the ASIPS refined version of the taxonomy along with all subsequently reported events; 608 fully coded events were considered for analysis. These 608 events used 337 of 421 possible codes. Forty-nine of these 608 cases were reported and coded prior to harm outcome information being available; we excluded these 49, leaving 559 cases for this analysis. Analyses included basic frequencies across three different taxonomy constructs. For identification through out this paper, these three constructs are labeled as Individual Code, Hierarchical Construct (care process level analysis), and Derived Construct (clinical activity level analysis) groupings. Since event reporting was voluntary, there was no denominator available to compute rates for presence of an event characteristic as defined by the construct groupings.

Description of harm

For this paper we used a definition of harm that includes clinical harm to the patient as well as future risk of harm to the patient or others.[13] Briefly, the degree of clinical harm in the ASIPS DMO taxonomy is classified as—

- minimal harm - a change in some physiological function that did not require medical attention, and the patient was expected to fully recover at the time of the report;
- moderate harm - decreased functioning of an organ system that is measurable clinically, but may not have been noticeable to the patient unless the organ system was stressed, and medical intervention—but not hospitalization—may have been required;

- severe harm - a major change in some organ function that typically would require hospitalization; or
- death.

Table 1. Domains, axes and constructs of Dimensions of Medical Outcomes used for coding and analysis in the Applied Strategies for Improving Patient Safety project

Domain 2: Outcome
Axis 2.1 Patient post event status
Axis 2.7 Outcome intervention/activity
Domain 3: Course of the event
Axis 3.1 Overall event type
Axis 3.2 Event location(s)
Axis 3.3 Intent of event
Axis 3.4 Activities leading up to event
Axis 3.5 Event cause(s)
Domain 4: Participants
Axis 4.2 Involved participant(s)
Axis 4.4 Contribution
Domain 5: The observation
Axis 5.5 Originator/discoverer of event
Examples of constructs used for analysis
Individual code
3.4.5.2.1 Correct surgical procedure with error in performance
Hierarchical construct
3.4.5.2. Correct procedure or activity with performance issue
Grouped codes under this Sub-axis
3.4.5.2.1 Surgery
3.4.5.2.2 Examination
3.4.5.2.3 Referral or consultation
3.4.5.2.4 Transfer or admission to facility (ED, OB, Psych)
3.4.5.2.5 Imaging
3.4.5.2.6 Lab test
3.4.5.2.7 Error in response to emergency facility, patient inquiry, nurse, consultant, or other professional
3.4.5.2.8 Diagnosis
3.4.5.2.9 History taking
Derived construct
Surgical procedure
3.4.5.1.1 Surgical procedure with complication
3.4.5.2.1 Surgical procedure with error in performance
3.4.5.3.1 Surgical procedure not performed
3.4.5.4.1 Surgical procedure incorrectly timed

While coded for each event, duration of harm was not used as a variable in this analysis. Finally, for this analysis we included "increased future risk of clinical harm" to the patient or others. Examples of these two categories include a missed diagnosis of diabetes for several years (future harm to patient) and an Rh-negative woman who was Rh-sensitized, due to failure to check a blood type during a spontaneous miscarriage (future harm to her next fetus). While we recognize physical and psychological discomfort within the harm axis, and the DMO taxonomy includes codes for these aspects of patient harm, we have not included these codes in this analysis. A detailed description of our approach to coding harm can be found in an ASIPS report[13] and online.[8]

Analysis

Cross tabulations with calculation of odds ratios were used to examine the ability of the taxonomy and its underlying constructs to describe patient safety events and to measure the strength of the associations between event characteristics and harm. The odds ratio describes the chances of patient harm occurring relative to harm not occurring, given the presence of a particular event characteristic. Resar[15] and Battles[16] have noted that the ultimate goal of patient safety activities is to reduce patient harm, but not necessarily eliminate all errors. Therefore, we chose to use patient harm as the major dependent variable in our analyses.

We analyzed the ASIPS DMO taxonomy to identify those individual codes within the hierarchy that associated positively or negatively with the harm (individual code analysis). We then analyzed the data by collapsing codes within the dimensions of the taxonomy's inherent hierarchy (hierarchical construct analysis). Finally, we analyzed the data based on clinical constructs (derived construct analysis). These constructs crossed sub-axes, many being predefined at the time the taxonomy was revised. Examples of each analytical framework are shown in Table 1. Some of the Derived Constructs were developed through an iterative group process prior to analysis. We then analyzed all three approaches to error classification to identify those codes and constructs that were associated with harm.

Results

The four individual codes associated with harm are shown in Table 2.

These codes include communication problems based on language barriers, clinician judgment, and lack of office safety systems. Overall, few individual codes are associated with the definition of harm used for this analysis. Results of the analysis based on the Hierarchical Constructs are shown in Table 3. This analysis examines the usefulness of the underlying conceptual basis of the DMO taxonomy—errors or problems based on the care process—to identify activities associated with harm. The 10 codes within this sub-analysis describe different aspects of drug related injuries, the importance of timing processes within the

Table 2. Individual codes associated with harm

Code Description	**Odds Ratio**	**95% CI**
Therapeutic intent	2.71	1.75–4.17
Language barrier	8.35	2.52–27.65
Judgment	2.36	1.34–4.16
No system exists	1.99	1.11–3.58

CI=Confidence interval

Table 3. Hierarchical constructs associated with harm

Within hierarchy code description	**Odds Ratio**	**95% CI**
Discrete event	0.44	0.27–0.71
Recurring event	5.98	2.52–14.20
Correct drug with wrong frequency/route/dose	4.11	2.54–6.64
Disclosure/explanation of need for test/treatment or exam	3.92	2.14–7.18
Mistimed procedure	1.95	1.28–2.95
Chart documentation	0.36	0.24–0.56
Drug error	4.14	2.69–6.39
Communication from another office	2.11	1.20–3.73
Patient care outside of office	1.89	1.19–3.01
Distraction	0.40	0.21–0.74

CI=Confidence interval

primary care office, and the importance of communicating information to the patient.

Harm was also associated with eight derived constructs (Table 4). These derived constructs, which are conceptually based on clinical areas such as errors of examination and diagnosis, or delays in therapy, highlight alternative views of the error event dataset. For instance, examination and diagnostic errors are both positively associated with harm in this view, but neither appears in the Individual Code analysis.

Looking across the three tables, several combinations of codes appear to offer different pictures of failures within a larger clinical process: Errors in communication from another facility; errors in failing to disclose the need for further tests, treatments, or exams; and delays in therapy are all positively associated with harm and identify a potentially important clinical pattern that warrants further investigation. The events coded within these three groups are not identical. Of the events that are in any of these three groups, only 1.8 percent are in all three and 15.9 percent are in two of the three. Another combination with apparent clinical relevance includes errors in communication from another office, errors involving patient care outside of the office, and errors in the referral

Table 4. Derived constructs associated with harm

Description of Construct	Odds Ratio	95% CI
Communication to patient	1.71	1.02-2.87
Clinical data	0.33	0.17-0.65
Error in diagnosis	2.18	2.99-8.53
Examination process errors	3.04	1.42-6.52
Referral process errors	2.43	1.06-5.56
Delay in therapy (medical/surgical or drug)	5.05	2.99-8.53
Error in knowledge/skill/judgment	2.26	1.42-3.60
Provider of record	2.12	1.40-3.23

CI=Confidence interval

process. Again, events coded with these three constructs don't entirely overlap, with 3.1 percent of the events appearing in all three constructs and 37.9 percent of the events appearing in two of the three constructs.

Our analysis also indicates that there are a number of DMO constructs that describe errors within the primary care office that are not associated with harm. These error categories include surgical procedures and other office activities (such as laboratory/imaging or functional studies) that are not performed (when indicated, as opposed to delayed performance), are performed incorrectly, or are performed without indication. While communication issues are associated with harm using all three analytical approaches, they are rarely the sole error within an event. Overall, we have identified a communication issue within 71 percent of events suggesting that communication plays an important role in most medical errors. Nonetheless, when communication is examined in relationship to the primary care office (the central locus of attention for ASIPS), instead of the more specific constructs identified in Tables 2, 3, and 4, it is not associated with harm. These larger patterns of communication include: communication totally within the office (between office staff/clinicians); communication into the office from any other location (including from the patient); communication out of the office to any other location (including to the patient); or communication unrelated to the office (including consultants to patient or patient to consultants).

Discussion

Approaches to classifying medical errors vary widely. We describe a system that facilitates a multidimensional analysis of events. While our highly detailed approach to coding requires a relatively large number of reports in order to examine the utility of individual codes, the DMO taxonomy results in a broad understanding of the process of errors within the primary care office. Results of our three different analytical approaches indicate that different views of the data highlight overlapping, though non-identical parts of the safety problem. The three views of the ASIPS error reports appear useful and support the use of a taxonomy that allows for various analyses of the same information. One view of our data indicates that primary care errors of concern include medications and delays in

performing activities. From a second view, promoting primary care safety is all about improving communication. Not all individual codes or theoretically derived constructs appear equally useful in identifying errors associated with harm in the primary care ambulatory setting, yet none of the approaches is clearly superior.

It is important to note that an analysis based on the relative risk of an error causing harm does not indicate that the errors outside of those in Tables 2, 3, and 4 are harmless. Even errors negatively associated with harm are still lapses in care and are not safe activities. For deciding which errors to address, Kaplan has promoted a process that uses a "risk matrix" calculation, which is the frequency of an event occurring multiplied by the likelihood of that event causing harm.[2] The ASIPS system does capture perceived frequency information. Given findings[7] that reporters are poor judges of immediate or future harm,[9] we are skeptical that reporters are likely to be good judges of the risk of harm for a given event. Thus, the present analysis provides an evidence-informed approach to help determine the likelihood of harm associated with a given event in a risk matrix calculation.

When moving toward interventions, we[17] and Newman[18] find it invaluable to look at the "stories" provided by reporters. As error report databases grow, determining which reports to pull for qualitative analysis can be difficult. "Sense making"[11] is an important attribute of any taxonomy used to classify and group medical errors. An approach using fuzzy logic (called case-based reasoning) to group reports has been described.[19] This sophisticated approach may not be widely available to all managers of medical error databases. The National Aeronautics and Space Administration and the Federal Aviation Administration system use a hierarchical keyword approach to searching for similar cases.[20] Our taxonomy coding can be likened to this keyword approach: we apply a set of hierarchical codes (words) to an event so that similar cases may be identified. By using various combinations of individual codes and constructs, and by looking at the intersection (where all cases have all attributes) or the union (where all cases must have at least one of the attributes) of these sets of events, there are many options for identifying similar cases. Events identified through these methods can then be evaluated using qualitative methods.[17]

Using the ASIPS DMO taxonomy to describe clinical activities involved within an error event, Table 2 (individual code analysis) represents the intersection of the process that has failed and the clinical activity for which it failed. Moving up the hierarchy, Table 3 (hierarchical constructs) represents process errors examined across clinical activities. Table 4, derived constructs, represents errors in clinical activities across processes. These three views of an event allow us to rapidly pull sets of events for secondary analysis, using either qualitative methods or secondary features of our taxonomy—such as specific diagnoses, medications, or procedure codes—to help elucidate potential interventions. Secondary analysis often involves combining quantitative and qualitative methods as outlined by Harris et al. in this compendium.[17]

Error reporting systems work at various levels within the health care system. Many systems are implemented within a single institution and are typically part of the institution's quality improvement process. Others, like ASIPS, work across

institutions, looking for common patterns of errors. While it would seem that within-institution coding should be less granular, as there may be fewer cases to analyze, and across-institution systems should be more granular, due to the potential for more error reports, our experience indicates this may not be the case. Within-institution problems are often specific to that workplace, and a finer degree of granularity may precisely highlight the errors of concern. Inter-system errors, with variations in how they present from institution to institution, may have different codes applied at the most granular level even though the same basic process error is occurring. Given the small number of Individual Codes associated with harm in our database, it is possible that the granularity of the DMO taxonomy is greater than necessary for the identification of inter-institutional error patterns.

Conclusion

Taxonomies developed to understand medical errors should be analyzed using quantitative and qualitative approaches to determine the useful level of detail based on empirical data, not just conceptual constructs. One of the important uses of codified error reports is to be able to sort events into categories for further, typically qualitative, analysis and sense making. The DMO taxonomy allows for classification of events from several different perspectives to facilitate these activities. As taxonomies continue to evolve, developers should pay attention to how the construction of a taxonomy facilitates the analysis and elucidation of errors, meriting further examination and warranting the development of practicable interventions. The development of a taxonomy that contains varying levels of granularity may allow multiple users to converse with each other while maintaining local control over the extent and complexity of coding undertaken. Further work is needed in developing such a taxonomy.

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