Developing a Nomenclature for EMR Errors

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Abstract. Latent medical errors may occur in electronic medical record (EMR) systems. Analyses of medical errors, including the cognitive theory of action and the systems approach, are described. Key aspects of EMR systems are presented and examples are provided. A nomenclature is suggested to improve reporting and communication about EMR errors. The nomenclature uses concepts of an error state and a precipitating event. The error state comprises an error element, an error condition, and an error context. The precipitating event comprises an event agent, and event task, and an event context. The event task includes a task object, a task action, and task parameters.

Keywords: medical errors, electronic medical records, electronic health records.

1 Introduction

In healthcare contexts electronic medical record (EMR) systems are gradually replacing paper-based records. One hope was that EMR systems would reduce the incidence of medical errors. Unfortunately, the use of EMR systems has brought new kinds of error, "EMR errors."

Discussion of the nature and causes of medical errors has resulted in different perspectives and classification schemes for medical errors. One wonders how to go about understanding, classifying, and preventing EMR errors. As awareness of EMR errors increases, we suggest that clinicians and information systems professionals could benefit from a standard way of talking about EMR errors. In this paper we suggest such a nomenclature for discussing EMR errors.

We start by discussing several different perspectives on medical errors. We then mention typical features of EMR systems and discuss EMR errors. After this we suggest a possible nomenclature for use in reporting and discussion of EMR errors.

2 Medical Errors

According to the Institute of Medicine (IOM), each year in the United States medical errors kill 44,000 to 98,000 people, more than breast cancer or highway accidents [1].

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During the last decade widespread attention to medical errors and their prevention has become part of the culture in most healthcare organizations [2], [3].

A variety of terms are involved in the general discussion of medical errors. The term "adverse event" is often used for an instance of patient harm not due to the natural course of a disease or illness. A "close call" or "near miss" is an event that could have resulted in an adverse event but fortunately did not, whether through sheer chance or being caught in time. Both adverse events and near misses can be seen as medical errors. Another distinction often used is between active and latent errors. Active medical errors are when the error event really happens – the patient gets the wrong medication, for instance. Latent errors are more in the way of conditions existing that under the right set of circumstances could give rise to active medical errors. An example would be incorrect or missing data in a patient's medical record that could result in a faulty treatment decision.

There has been much discussion within healthcare about how and why medical errors occur and how they should be classified. Two different perspectives on how they occur are represented by the cognitive theory of action and the systems approach.

The cognitive theory of action seeks to understand errors in terms of the psychological processes of an individual agent or actor. Donald Norman famously divided errors into the two basic classes of mistakes and slips. Mistakes are errors in intention, while slips are errors in carrying out the intention [4]. Norman and others expanded the analysis to delineate specific psychological steps or stages in the action process. Zhang et al, expanding on Norman, claim any simple action proceeds through seven stages of execution and evaluation: establishing a goal, forming an intention, specifying an action, executing the action, perceiving the system state, interpreting the system state, and evaluating the system state [5]. A mistake or slip could occur through a failure to properly carry out any of these stages. For example, a mistake could occur through a nurse misunderstanding the meaning of an alert message on the computer screen (failure in interpreting the system state), while a slip could occur when a physician trying to delete a duplicate chart note accidentally selects the wrong button (failure in executing the action). Various analysts believe that error occurs during the action process due to a lack of attention or through degradation of the user's internal representational model of the event [6].

A different perspective on error, though one not necessarily incompatible with the cognitive theory, is represented by the systems approach, which focuses not on psychological processes but on faulty systems. A famous proponent of this approach is James Reason. Reason claims the traditional "blame the person" approach to error overlooks the role of the larger context of systems. Error occurs when multiple systems fail, much like what happens when all the holes momentarily line up on adjacent slices of Swiss cheese [7]. Applying the systems approach to medical errors, Leape claims we must analyze proximate and ultimate causes to determine the multiple contributing factors or root causes that resulted in the error, and then we should redesign the system or systems that failed to make it harder for the error to occur [8]. For example, if someone makes an error after bring interrupted, don't focus on blaming that person but instead on changing the environment to reduce interruptions. Instead of retraining an individual to more carefully distinguish between two look-alike medication packages, change the packages [9]. On this view, medication errors from drug-drug or drug-allergy interactions are not caused by careless individuals as much as faulty or nonexistent checking systems.

Besides attempting to understand medical errors, analysts have attempted to classify such errors. Given the variety of medical error classification systems available perhaps what anyone thinks of as the "best" system will be the one most suited to their use of it. In arguably the most comprehensive effort, JCAHO-sponsored investigators gleaned key insights from numerous previous attempts and from industry experts to arrive at five category types (called "root nodes"): impact (harm to the patient), type (processes that failed – such as communication, patient management, or clinical performance), domain (setting and persons involved – such as general hospital, emergency department, etc.), cause (factors and agents – such as system failures or human failures), and prevention and mitigation (measures to reduce occurrence and effects). These primary categories were further divided and subdivided, eventually resulting in over 200 categories of medical error [10].

3 EMR Systems

Traditionally medical records consisted of paper-based charts, which are patient-specific folders or binders containing paper notes on diagnosis and treatment, lab test results, and related information. Physician orders for lab tests, medications, and procedures likewise traditionally are provided on paper forms. Records of physician orders are usually included in the patient chart.

Paper-based records suffer from many inconveniences and limitations, such as the need for large storage space if there are many patients, the unfortunate ease with which a chart may be misplaced, and the fact that it is difficult for more than one individual at a time to access a paper chart. Paper-based records and orders are susceptible to other problems such as documentation errors and misinterpretation of (sometime almost illegible) handwritten records or orders.

Gradually paper-based charts are being replaced by electronic medical record systems. Likewise, paper-based ordering is being replaced by computerized physician order entry (CPOE); CPOE functionality is often incorporated into or integrated with EMR systems. Within the U.S., many different EMR (and CPOE) systems have been developed by different hospitals or are offered by different vendors, and now professional organizations are playing an increasingly large role in supporting a common set of functions. The Institute of Medicine has defined important functions for any EMR system, including managing basic health information, results management, order entry and management, decision support, electronic communication, patient support, administrative processes, and population reporting [11]. To guide development of EMR systems, the Health Level 7 Standards Development Organization has created a standard of more than 125 EMR functions, including direct care functions such as health information capture and management, care plans, medication management, orders and results management, clinical decision support, and clinical communication. They also specified supportive functions such as provider directories, registry notification, and research and reporting, and they listed information infrastructure capabilities such as user access management, standards, and other administrative functions [12]. The Certification Commission for Healthcare Information Technology (CCHIT) has attempted to push a standard by developing a set of

functionality criteria required for any healthcare electronic record system to merit their certification [13].

Apart from any pressure created by such mandates, it stands to reason that while EMR systems may vary in appearance, navigation, and operation, they will all try to do mostly similar sorts of things because, within the U.S. anyway, healthcare services and medical records have become fairly standardized. There may be variation among configurations of EMR systems for certain specialties, such as pediatrics, and among different contexts, for example, hospitals as opposed to small ambulatory care private practices. But an EMR system would be worthless if it could not store documentation of clinical encounters between healthcare providers and patients or data about patient medications. So, as recognized by professional organizations, much of the functionality will be similar. Functionality might be thought of as grouped into EMR "modules." A typical module might be "chart notes" or "chart note management" that allows users to create, view, and manage notes that describe clinician-patient encounters or visits. Examples of other EMR modules would be patient demographics, medications, allergies, problems (diagnoses), orders (CPOE), results (lab tests), clinical alerts, and clinical communication.

An EMR system will also have supporting functions such as patient search capability, electronic signatures, and reporting. As is common practice in the use of other information systems, EMR systems may limit user access to functionality based on role. This allows users to be able to do what they need to do without having the ability to do what they don't need to do. Examples of roles are shown in table 1.

Table 1. Examples of EMR roles

Role	Privileges
Physician	Create, electronically sign, and close chart notes, place orders, full viewing
Nurse practitioner / physician assistant	Similar to physician but may need physician co-signature on chart notes and orders
Nurse	Similar to physician but ability to create and sign notes and orders may be limited
Scheduler/Clerk	Limited "view-only" ability for notes
System administrator	Ability to correct and delete chart notes and data entry errors throughout system; manage users in system

As mentioned, EMR systems are used in a variety of clinical settings, both in hospital and in ambulatory clinics and practices. Computers can be located at nursing stations, physician offices, front reception desks, exam rooms, hospital patient rooms, and even on mobile carts or freestanding laptops, tablet computers, and PDAs. For configuration purposes, within a hospital or multi-branch clinic there may be the need to distinguish in the system among access from different offices. So, for example, a chart note created at the main clinic might need a different letterhead address than a note created at a branch office. Table 2 presents examples of clinical contexts.

Table 2. Examples of clinical contexts

Main office
Cherry Street branch office
Exam room A
Nursing station, 4th floor
Physician office, Dr. Smith
Operating room #3
Patient room, #412
Mobile cart, surgical floor
Roaming laptop, assigned to psychiatry
PDA, assigned to Dr. Jones

An important reason for the documentation in an EMR is to make information available for future decisions. From the perspective of distributed cognition theory, both paper-based and electronic medical record systems are external aids that greatly affect the decision-making processes of physicians and other clinicians. Consider a physician who, perusing a list of chart notes completed by various clinicians on a particular patient, desires to see the last chart note he composed on that patient so as to refresh his memory about the treatment plan he developed for a particular problem of the patient. To make finding this note easier he performs the task of sorting the chart note list alphabetically by physician name. To better understand such an action, one could analyze this task into components, using, for example, the concepts of *event*, *agent*, *object*, *action*, and *parameter*. The instance of performing the task is an *event*. The *event agent* (here a physician) performs an *event task* (sorting the chart note list alphabetically by physician name). The *event task* comprises a *task object* (chart note list), a *task action* (sorting the chart note list), and *task parameters* (alphabetically by physician name). These concepts will be useful later in this paper.

Let's turn to consider EMR errors. Medication errors and wrong-site surgery probably get the most headlines, but errors also occur in medical records and physician orders. Handwriting and the use of dictation and transcription can lead to data errors and misinterpretations in paper-based medical records and ordering systems. One hope for the adoption of EMR (and CPOE) systems was that the occurrence of medical errors of various kinds would be reduced, for example by streamlining documentation and ordering, by making important information more readily available, and by providing decision-support tools. Computerization may well have reduced some types of error, as well as increasing convenience of access, but unfortunately the use of computerized systems seems to have created new kinds of error. For example, now that medical records are on the computer, clinicians can inadvertently copy and paste sections of notes into the wrong place or even the wrong patient's chart, accidentally delete unclosed chart notes, and draw the wrong conclusions about patient progress by misinterpreting lab results displayed on poorly designed summary screens.

Several studies have shown various types of error or failure of expected outcomes upon deployment of ordering systems [14] [15]. Ash et al found instances in which "patient care information systems" (their term for systems such as EMR and CPOE

systems) "seemed to *foster* errors rather than *reduce* their likelihood." Focusing on human-computer interaction, Ash et al found such systems resulted in problems in the process of information entry/retrieval and in the processes of communication and coordination. These problems are of various kinds. For example, user interfaces (screens, navigation) sometimes were ill-suited to busy healthcare work environments, documentation created via pre-supplied phrases and sentences reduced readability, overly busy screens and too-frequent intrusive alerts caused "cognitive overload," and there was insufficient error-checking by the system [16].

We suggest use of the term "EMR error" for, within an EMR system, any incorrect data or faulty functionality, any aspect of the system not functioning according to design specification or user requirements, any incorrect design specification or user requirement, and any significantly suboptimal usability. We do not restrict EMR errors to problems from human-computer interaction; programming errors and hardware failure are included. Now of course a misplaced character in an obscure part of a chart note might be irrelevant to patient care, but significant EMR errors conceivably could lead to real instances of patient harm. In contrast to "active" medical errors such as wrong-site surgery, significant EMR errors might be seen as "latent" medical errors in that they create conditions that could result in active medical errors (e.g., diagnostic or treatment errors) that might compromise patient safety.

Clinicians using an EMR system who notice (significant) faulty data or functionality will likely report the problem to technical support or system administrators in their institution or working for the EMR software vendor. This could occur by phone call, email message, or creating a "ticket" in a help desk reporting system. The tech support person will attempt to understand the nature of the problem, and when and how it occurs, and then they or someone else will work to determine the cause and the appropriate resolution or prevention measures. This kind of EMR error reporting, analysis, and resolution requires cooperation and effective communication among clinicians, technical support staff, and management, but communication may be hindered if there is no good way of describing or referring to the problem. The user may have a basic understanding of what happened, but to tech support the user description of a problem may consist of vague, incomplete, or confusing phrases such as "the menu is missing things," "I can't see the bottom of the screen," or even simply "the system doesn't work right." What menu or screen is involved, what specifically is wrong with it, or in what way are things not right? Such vagueness complicates the work of tech support because lengthy phone conversation, observation, and attempts at recreation may be needed before the precise nature of the problem even can be understood. In an online system, tech support may have created drop down menus asking for choices from users when the ticket is first submitted, this to try to route the problem to the right person, but the menu items may be beyond the ability of a typical clinician to decipher or decide upon. How many typical users can say whether it is a hardware, software, application, operating system, or network error? Beyond such initial reporting from the user, even staff investigating the error may lack a convenient way of referring to the problem. The problem may be assigned a tracking number to uniquely identify it, but this number will fail to tell anyone whether and in what way it is related or similar to other problems.

4 A Suggested Nomenclature for EMR Errors

To facilitate worthwhile discussion concerning EMR errors we suggest development of a more nearly standard nomenclature or vocabulary. The concept of a standard nomenclature or vocabulary should be nothing new to clinicians used to standardized clinical vocabularies and codes such as ICD-9 diagnosis codes (for diseases) and Current Procedural Terminology (CPT®) codes for office visits and procedures. Standardized terms and codes for diseases and procedures have been used for years to avoid situations in which every clinician has his or her own distinctive set of names. We are urging that a similar (though less extensive) standardization effort be undertaken for EMR error reporting and analysis to improve the quality of EMR error communication, discussion, and resolution. We are not suggesting a numerical classification scheme but rather merely the adoption of some standard way of talking of EMR errors.

In light of the plethora of efforts expended by many parties during the last decade or so to try to develop the best classification system of medical errors, seemingly not stemmed by the comprehensive JCAHO effort [17], we are not here proposing an ultimate classification system or ontology for EMR errors. But such classification efforts immediately suggest two possible categories for use in such a nomenclature: "type" and "cause."

Our system does allow for possible use of the concept of an EMR error "type," but it remains to be seen what the best options for type might be and whether this concept would be useful for any nomenclature attempting to be relevant to actual discussion of EMR errors in the field, i.e., clinical settings and conversations among clinical and information systems personnel trying to identify and resolve real EMR error instances. Medical error "types" mentioned in most academic discussions are likely too abstract or vague for feasible use by actual clinicians, whether or not such categories are helpful to academics trying to understand the nature and causes or such errors. Common EMR error types might be *data* (incorrect or missing data), *functionality* (some function that needs to work is not working or not working correctly), and *performance* (the system response is perceived as slow), though one also thinks of such possibilities as *communication*, *data entry*, *screen layout*, *screen navigation*, *missing button or menu item*, etc. Unfortunately the typical clinical user might have difficulty determining the proper type for their error with even a very simple set of options because they are not focused on classifying computer system errors, they are focused on performing clinical tasks. So we hesitate to pontificate about what options should be available for type or even whether it should be used.

In light of the controversial topic of whether the "cause" of a medical error is to be found in psychological processes (depicted in the cognitive theory of action, for instance), faulty systems (the systems approach to error), or something else, we suggest that "cause" not be included as a basic category or element in our nomenclature. It is unrealistic anyway to expect the user who reports the problem or those who subsequently discuss it to be able to correctly tell you the ultimate or root cause or type of cause of the error prior to the investigation. Also, no matter what user options for elements or categories are chosen, the option terms used should, if possible, not

be unduly technical but rather something the average user can understand. These considerations are meant to try to ensure that any nomenclature developed for use in discussing EMR errors will be something useful in a first-pass, preliminary, and elementary discussion of the error.

We distinguish between two aspects of the type of nomenclature that we have in mind. First are the concepts, categories, or elements of the nomenclature; these are the kinds of things we take note of or use to talk of the error. Second, within each of these elements are the values or options from which one might choose. Below we offer suggestions about the error elements or concepts that might be useful in this effort, as well as particular values or options within each element, but perhaps pilot studies using this scheme and analysis of its usefulness will be the ultimate arbiters of the optimal elements and options.

Our suggested nomenclature includes the concepts of an *error state*, an associated *precipitating event*, and related subconcepts. To put it simply, the *error state* is what is wrong, and the *precipitating event* is what the user was doing when they noticed something wrong. Table 3 displays the concepts and subconcepts in the nomenclature.

Table 3. EMR error nomenclature concepts and subconcepts

Concept	Subconcepts
Error State (what is wrong)	*Error Element* (incorrect datum or function)
	Error Condition (what is wrong about element)
	Error Context (location of element in system)
Precipitating Event (what the user was doing)	*Event Agent* (user)
	Event Task (activity being performed in system)
	Task Object (involved in task)
	Task Action (what was being done)
	Task Parameters (modifiers)
	Event Context (clinical or admin. context)

The *error state* is what is wrong, incorrect, or malfunctioning in the system that makes the situation the occurrence of an error. The *error state* comprises an *error element* (the incorrect datum or function), an *error condition* (what is wrong or incorrect about the error element), and an *error context* (for example, the screen, textbox, button, report, EMR modules, etc. in which the error element is located).

As an example consider the situation of a physician who notices that dates suddenly go missing after sorting a list. The *error state* would be "chart note dates missing from chart note list in chart note management module." The *error element* would be "chart note dates," the e*rror condition* would be "missing," and the e*rror context* would be "chart note list in chart note management module."

Table 4 provides examples of error elements and error conditions. In that table a sample condition is associated with each element, though of course other conditions could be associated with that element.

Table 4. Examples of error elements and error conditions

Error Element	Error Condition
Chart note	missing
Date	incorrect
Blood pressure	transposed
Screen	misaligned
Summary screen	poorly designed
Patient address	outdated
Medication dosage	inapplicable
Medication SIG menu	working incorrectly
Chief complaint	duplicate
Problem list	unsorted
Plan	irrelevant
Drug allergy	expired
Food allergy	confusing
Save button	misleading
Edit chart note function	not working
Results display	ungrouped

Associated with the error state is a *precipitating event*, which is, from the user's perspective, what gave rise to the error state or at least what the user was doing or attempting to do right before or when the error was observed. In fact this precipitating event could have played a causal role (triggering the error) or simply a revealing role (allowing the error to reveal itself). But the user will not necessarily know whether the precipitating event had a causal role, and as mentioned, the notion of the "cause" (as opposed to causal factors) may be controversial. In our nomenclature the precipitating event will feature an *event agent* (the user performing or attempting a task), an *event task* (an activity being performed or attempted), one or more *task objects* (involved in the task), a *task action* (what was being done), one or more *task parameters* (specifics about the way the task was done), and an *event context* (the clinical or administrative context of the precipitating event). Please refer to table 3 for clarification.

Event agents are typical user roles correlated with different levels of access in the system; examples were listed in table 1. The *event task*, including *task object*, *task action*, and *task parameters*, were already discussed earlier in this paper in our discussion of EMR systems and are going to reflect the many tasks one can accomplish with an EMR, such as creating a chart note, entering a patient's prescription, sorting, deleting, copying, etc. The event context could be "Main office exam room A"; additional examples of the *event context* were listed in table 2.

Our suggested nomenclature permits post-coordination and is intended for use in documenting and reporting EMR errors, which would facilitate improved communication between users and issue solvers. Ultimately, using this type of nomenclature to group similar cases could allow trigger case-based reasoning and provide for timely solutions.

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