

Intelligent Simulation Model To Facilitate EHR Training

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Abstract

Despite the rapid growth of EHR use, there are currently no standardized protocols for EHR training. A simulation EHR environment may offer significant advantages with respect to EHR training, but optimizing the training paradigm requires careful consideration of the simulation model itself, and how it is to be deployed during training. In this paper, we propose Six Principles that are EHR-agnostic and provide the framework for the development of an intelligent simulation model that can optimize EHR training by replicating real-world clinical conditions and appropriate cognitive loads.

Introduction

The growth of electronic health records (EHRs) in the United States in the last decade has been meteoric, primarily as a consequence of the Health Information Technology for Economic and Clinical Health Act (the HITECH Act), enacted under Title XIII of the American Recovery and Reinvestment Act of 2009. The reimbursements afforded to institutions and individuals as a consequence of “meaningful use” regulations have also added substantially to the impetus of EHR adoption¹.

As EHR use has grown, the potential for improvement of healthcare delivery quality has also increased², but so has the potential for causing patient harm associated with EHR use^{3,4}. This phenomenon can be attributed to a number of reasons, primarily because the addition of technological innovations into complex healthcare systems appear to be associated with a new breed of errors, a process which has been termed “technological iatrogenesis”⁵.

EHR training plays a critical role not only in fostering end-user EHR adoption, but also in their ability to efficiently use the EHR while delivering clinical care⁶. This realization led the Office of the National Coordinator for Health Information technology (ONC) to endorse the creation of curricular materials for entry-level HIT professionals that included hands-on learning with an EHR⁷. However, a standardized learning plan is not available to healthcare organizations that are implementing EHRs. Further, different EHRs, and even different implementations of the same EHR, tend to have variations in their interface, which makes the process of finding and reviewing information more difficult for end-users.

Typically, clinicians using the EHR need to find relevant information in a rapid fashion, often while they are multitasking, and operating in an environment that can be distracting⁸. Training clinicians to operate efficiently in such an environment while using the EHR in a manner that optimally facilitates medical decision making and patient care requires the development of EHR training protocols that best aid learning. Further, since the time clinicians spend in EHR training is in essence time they cannot devote to direct patient care, optimum EHR use training needs not only to be comprehensive but also efficient with respect to the use of clinicians’ time. Training must take into account the needs of all of the varying professional groups which interact with the patient. Finally, EHR training programs also need to consider the unique characteristics and assumptions of the community of practice they serve⁹, the degree of comfort that each individual clinician has with the EHR, and their baseline proficiency.

Many models of EHR proficiency training have been proposed, but the most commonly used formats are formal classroom/lab, and one-on-one/at-the-elbow training¹⁰. Most use a training or simulated EHR environment, since the use of real-life situations to impart EHR training has critical drawbacks, including the fact that imparting training in

a production environment can introduce errors into a real patient's chart, that no two real life cases are identical (i.e. the lack of replicability), and that training using actual patient records may violate Health Insurance Portability and Accountability Act of 1996 (HIPAA) privacy rules. An increasing body of literature describes the potential of simulation training to improve acquisition of clinical skills, training of health care teams to effectively navigate complex systems and improve teamwork, communication and shared decision making. While the technology to improve the fidelity (realism) of simulation activities has improved dramatically, there are still significant barriers and limitations to incorporating the EHR into clinician training regimens. Firstly simulation environments are often very different than their production counterparts, marginalizing their utility when provider knowledge and use of the actual operational clinical information system need to be emphasized. Second, EHR training environments are not populated with actual patient information (in deference to HIPAA privacy rules) and typically contain just a few cases populated with sparse data. Typical cases within EHR training environments rarely recapitulate the complexity and specific clinical information encountered by end-users providing clinical care within the scope of their training, and rarely replicate the level of data density encountered in real-world utilization. Third, EHR simulations are typically not associated with the "cause-and-effect" real-time cascade of events that is seen in real life clinical settings – for example ordering an antibiotic for a febrile patient with an infection results in the normalization of their temperature and a change in their clinical status which results in the discontinuation of the antibiotic after an appropriate period of time.

In this paper, we describe a model for developing and building realistic, clinically complex simulations that can be used for optimizing end-user EHR training, in a manner that facilitates the simulation of realistic clinical cognitive loads as end-users participate in simulated activities.

The case for simulation

The primary advantage of using simulations for training is that they allow learning activities to be absolved of any risk of harming real patients. Simulation tools and technologies have advanced dramatically over years, and now allow both the training of classical procedural skills such as airway management of trauma patients in the prehospital setting¹¹ or advanced cardiac life support (ACLS)¹², as well as more innovative learning, such as the use of simulation in teaching clinical judgment skills¹³ or in disease management and prevention¹⁴.

By replicating complex real-life situations¹⁵, simulations allow the evaluation of clinical skills and competence in a comprehensive manner¹⁶. Further, we have used simulations to assess EHR safety¹⁷ and demonstrated that participation in EHR simulation helps clinicians better recognize patient safety issues¹⁸.

Characteristics of an optimal simulation-based EHR training protocol

However there is still a need to develop an optimal EHR training protocol that utilizes simulation effectively. There are three primary barriers to optimal simulation use at present which will need to be overcome. First, default "training" cases included with most EHR distributions are overly simplistic, and contain sparse data. This is very different than real life patient records, which are often complex and contain a plethora of data. For example, a patient admitted to a typical ICU may generate more than 1,500 data points each day they are in critical care¹⁹. Optimally training an ICU physician would require the use of simulation cases that replicate at least a significant proportion of the data complexity that they would be expected to encounter when they are providing direct patient care.

Second, EHR training should also be able to replicate the cognitive load that clinicians are subjected to when they peruse the patient chart. These will allow the clinician to understand and mitigate the errors of cognitive that are closely associated with their task load and EHR use patterns²⁰. For example, while EHRs can reduce errors associated with physician order entry, they may also paradoxically increase them^{21,22}. Typical EHR training cases focus on entering one, or at most a few orders into the system in a setting where cognitive load is minimized, thus

minimizing the likelihood of any errors occurring during the training process, and missing a rich opportunity to emphasize a specific training objective that would allow end-users to identify, correct and mitigate a common potential cause for patient harm.

Third, the current EHR training paradigm continues to focus on the **structure** of the EHR as the prime anchor for training, rather than the **function** of the EHR within the context of the cognitive tasks the clinician needs to perform using the EHR. A clinical simulation scenario is better suited to contextualize the use of the EHR in clinical settings than the traditional classroom approach where a specific topic of EHR functionality is first identified, followed by a demonstration of the task(s) required to achieve the desired functionality. By migrating away from a “learn-by-rote” model of EHR training towards “case-based” model of EHR training, learning objectives are better reinforced and clinicians are able to translate the concepts they have learned in their EHR training session much more effectively to their clinical practice.

Building the infrastructure

In order to achieve an effective training paradigm, the EHR simulation environment itself should be capable of achieving the necessary degree of fidelity that replicates the system in the clinical setting. To accomplish this in an optimal fashion, one would employ a simulation version of the clinical EHR that would allow for full utilization of system functionality without risking either breach of patients' protected health information or potentially impacting other connected systems (e.g. pharmacy or billing clinical information systems).

In our experience, the simulated instance of the EHR should contain the following characteristics: first, it should be routinely “cloned” from the existing production environment (with all patient identifiable information deleted) thus allowing users to have the most up to date version of the EHR, as well replicate the individual provider’s user-specific customizations, macros and order sets. Second, the system must be populated with simulated medical records that have been designed specifically for the workflow being assessed, with cases that reproduce the clinical complexity and scenarios encountered in actual practice. Third, cases must be temporally aligned with the proposed exercise. Specifically, complex cases need to be carefully designed and built into the system in advance of any training exercise. Rather than populate the simulation environment with patient data that exists in the distant past (as perceived by the end-user), it is essential that patient data, if appropriate, be carried forward to the day of training. Finally, real time report results need to be generated directly into the EHR rather than be verbally communicated to the end-user during the simulation activity. Ensuring this feature is often the most difficult; depending on the exercise, results may need to be customized “in the moment” and informed by the performance of trainees. However, this functionality is essential for replicating realistic EHR use patterns in high-stress situations, especially when considering end-user information processing, as well as subsequent diagnostic reasoning and shared decision making.

Once the simulation environment of the EHR is created, it must be deployed in a manner similar to its clinical use. When incorporating the EHR into other simulation activities, it is important to ensure that the simulation workstations resemble, at least in terms of form and function, the actual workstations used in the clinical environment. This includes replicating monitor size, the use of mobile workstations and ergonomics similar to the clinical care environment when applicable. This is important to not only eliminate potential confounders introduced by unfamiliar hardware, but also fosters cognitive thinking in a fashion that mimics real life conditions. Ideally, once established the actual simulation center itself could be EHR agnostic, allowing multiple EHRs to be utilized in simulations depending upon the needs of the organization, the tasks at hand and the learners themselves.

Conceptualizing an Intelligent Simulation Model

Engaging in simulation activities allows learners to move from the knowledge or comprehension levels of Blooms taxonomy to application and analysis. The provision of high fidelity simulation that replicates a level of cognitive

load comparable to real life clinical situations may also allow learners to synthesize knowledge for subsequent application in real life patient care²³.

Simulation activities promote learning without endangering patient safety, utilizing standardized replicable scenarios. High fidelity simulations allow learners to engage in scenarios that are closely reminiscent of real life situations, and thus engage in analogical reasoning that integrates new information learned during the simulation to prior accrued experiential clinical knowledge, thus improving competency²⁴.

We have previously described a model for intelligent case design²⁵ that emphasized a patient-centric record and utilized an interprofessional team-based approach to designing complex cases. Additionally we have also described a framework that allowed us to test how high fidelity simulations can be utilized to test new EHR training models or interface designs in a manner that facilitates error recognition and improves patient safety¹⁷. We built upon this framework and utilized intelligent cases to facilitate a model that allowed the generation of realistic cognitive loads as learners participated in the simulation activity. The intelligent cases designed by us specifically allowed end-users to identify both normal as well as abnormal patient data by recognizing low and high-end cutoffs in the context of the patient's clinical presentation rather than depending on the traditional defined range. Our cases included both common as well as rare data, at a level of density that reflected real-life clinical situations. The data also allowed end-users to not only find relevant data, but also to recognize when relevant data was missing from the user interface screens they were expected to use. And finally, our cases incorporated best practice and meaningful use criteria to emphasize the need to incorporate standards of care into efficient EHR use¹⁷.

Deploying cases designed using the principles delineated above allows end-users to be trained using a model that closely replicates the cognitive load they encounter while taking care of patients, and allows them to anchor simulation-based EHR training in the context of providing clinical care. However these cases are best deployed using a simulation paradigm for EHR training that is also based on intelligent design principles.

Building intelligent simulations

We propose Six Principles for effective Intelligent Simulations that foster effective EHR training. These Principles emphasize the need to provide a training experience that closely mimics real-life cognitive and decision-making paradigms, and allow EHR training to occur in the context of the clinical care that the end-user is trained to provide. They are independent of the EHR being used to conduct the simulation.

[1] EHR training should be conducted in the form of a simulation exercise that describes a clinical scenario familiar to the learner. The training session should be anchored utilizing the clinical context of the simulation, rather than on specific elements of EHR functionality. The simulation exercise should focus on pre-determined optimal clinical outcomes that define efficient EHR use, rather than the EHR-specific tasks themselves. For example, if the simulation trains the end-user to learn order entry functionality for prescribing medications, the clinical context (for example a patient develops an abnormal heart rhythm necessitating the prescription of a specific medication to counter it) should drive the training session, and success should be aligned to the end-user's ability to visualize and examine specific information within the EHR, rather than focus only on the EHR itself -- in the case of the example noted above, one success measure could be the ability of the end-user to visualize and recognize the patient's changes in clinical and vital signs after prescribing the appropriate medication.

[2] Simulations should replicate real life processes. This implies that cases should not be too simplistic (as is the case with most current training cases) or divorced from reality. Clinicians should be immersed in the environment as much as the simulation infrastructure allows, and cognitive skills utilized in real-life settings should be brought to bear as the simulation training progresses.

[3] The simulation should use a standardized case structure and format. Most importantly, these cases should replicate both the clinical complexity as well as the workflows of the clinician being trained, with adequate data

density and complexity. In addition, two vital characteristics of real-life cases need to be included within the intelligent simulation. First, the structure of simulation cases should replicate real-life conditions. Clinical scenarios should be plausible, and documentation within the patients chart (such as clinical notes, X-rays or laboratory tests) should reflect the clinical condition in a manner that replicates real-life considerations. Second, the diagnostic reasoning processes that the trainee brings to bear should mimic real-world cases, thus attempting to maintain intellectual fidelity in addition to data fidelity.

[4] Each simulation needs to address the routine “cause-and-effect” phenomenon that characterizes EHR use in the clinical setting, specifically with respect to the temporal sequencing of data. Typically, training EHR cases showcase events that have occurred in the past (typically on the day the cases were incorporated into the instance). This creates an artificial temporal sequence that end-users usually find unrealistic. By utilizing “rolling” cases that allow patient data to be accessed as they would in real life (i.e. yesterday’s lab values can be accessed by the end-user scrolling back by one day, and last week’s vitals by going back a week in time) the cognitive load placed on the learner is realistic and sustained. Complex cases will need careful design to reflect this, and patient data will need to be routinely carried forward up to the day of testing. End-users will also need to access real-time reports as they engage in training. This allows appropriate information processing and use of the EHR in a manner that fosters diagnostic reasoning.

[5] Simulations should be conducted using an instance of the EHR that has been replicated from the production environment. The training instance should incorporate all the individual customizations applicable to the end-user receiving training, and also allow the use of protocols (for example logins, macros) that are identical to those utilized in the production environment. This allows end-users to learn using the same screens and customized features that they are familiar with when they take care of patients, thus optimizing their level of learning with the EHR.

[6] Simulation training protocols should be developed by an interprofessional team. The practice of medicine today is clearly a team activity. We believe that the perspectives of members of an interprofessional team are invaluable in developing simulation cases and protocols for specific disciplines of clinicians. For example, a nurse may have insight that allows a more sophisticated EHR training protocol to be defined for a group of physicians, or a pharmacist may contribute significantly to the EHR training of nurses. Involving multiple disciplines in the development of EHR training protocols also fosters collaboration, and strengthens patient safety.

A summary of the six design principles delineating the focus and evaluation paradigm associated with each individual principle is presented in Table 1.

Tailoring simulations

Intelligent simulation designs incorporate clinical scenarios that replicate the cognitive load that clinicians experience when they are actively utilizing the EHR to provide patient care. This requires not only calibrating the amount and complexity of data presented during the simulation, but also customizing the simulation to the specific role of the clinician. For example, a case targeted to physicians may need additional customization to ensure that it retains adequate high-fidelity and cognitive complexity for nurses, pharmacists or other non-physician clinicians who may participate in simulation activities. Cases will need to be tested to ensure that pertinent and appropriate data elements are displayed not only on physician EHR screens, but also on role-specific EHR screens for any non-physician clinicians who may participate in the activity.

Further, the level of cognitive load that can be assumed by individual clinicians is also dependent on their clinical competency, and experiential factors such as their level of training. A medical student participating in a high fidelity EHR simulation assimilates and processes clinical data differently than an attending physician. Developing

intelligent simulation requires designers to acknowledge the importance of calibrating both the complexity and the cognitive load of the simulation to match the level of competency and experiential learning of individual subjects.

Table 1. Six Design Principles for building effective Intelligent Simulations

Design Principle	Focus Of Simulation Activity	Simulation Evaluation Paradigm
Incorporate EHR training elements within the contextual framework of the clinical simulation activity	Simulation activity should be anchored using clinical aspects of the scenario, as opposed to EHR functionality	The clinical context should inform EHR use and data retrieval by the subject, with evaluation measures driven by the clinical context as opposed to EHR design-related elements
Replicate real life processes with adequate levels of calibration	Simulation activity should reflect a high level of realism and be framed in context that is appropriate for acuity, level of care, and clinical cognitive load	High fidelity simulation mandates immersion of the clinician in the simulation, to the best extent possible within the constraints of the environment
Utilize a standardized case structure and format, and duplicate real-life clinical workflows	Simulation activity should reflect appropriate level of data complexity and density, feature plausible clinical scenarios, and replicate the cognitive load encountered by clinicians in real life clinical care settings	Data complexity and density, both with respect to individual data elements as well as trends, should reflect the level of complexity expected from the clinical scenario. Documentation and data can be reviewed by clinical subject matter experts to ensure that they maintain both data and intellectual fidelity
Allow optimum cognitive reasoning by facilitating the "cause-and-effect" phenomenon of EHR data retrieval	Simulation activity case design should focus on ensuring that data is appropriately sequenced temporally, to facilitate recognition of trends. Case designers should also incorporate real-time reports into the simulation activity to foster realistic diagnostic reasoning	Case testing prior to conducting simulation activity should confirm that patient data is available to subjects in a fashion that mimics real life, i.e. with appropriate adherence to temporal sequencing pertinent to the clinical scenario
Replicate simulation instance from production environment	Simulation environment should closely duplicate the production equivalent. Individual clinician customizations should be brought forward from production to simulation environments	The simulation environment should be audited to ensure individual end-user customizations (logins, documentation macros, order sets, institution or department-specific clinical decision support rules) etc.) have been replicated prior to initiation of simulation activities
Develop simulations utilizing an interprofessional team	Interprofessional clinical perspectives should be actively solicited while building cases for simulation activities	The team building intelligent simulation cases should comprise of members from different clinical disciplines that truly reflects the interprofessional constitution of the team delivering patient care in a similar clinical real-life context

Conclusion

Using simulation infrastructure deliver end-user EHR training can optimize learning, clinician efficiency and promote patient safety. Rather than continuing to utilize current training models, developing a strategy that incorporates intelligent simulation within clinician EHR training programs has the potential to improve how clinicians use the EHR, reduce patient harm, and promote superior clinical quality of care.

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