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Brief Communications

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Regenstrief teaching electronic medical record (tEMR) platform: a novel tool for teaching and evaluating applied health information technology

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ABSTRACT

The objective of this study is to provide an overview of the Regenstrief Teaching Electronic Medical Record (tEMR), how the tEMR could be used, and how it is currently being used in health professions education. The tEMR is a derivative of a real-world electronic health record (EHR), a large, pseudonymized patient database, and a population health tool designed to support curricular goals. The tEMR has been successfully adopted at 12 health professional, public health, and health information technology (HIT) schools, with over 11 800 unique student users and more than 74 000 logins, for case presentation, to develop diagnostic and therapeutic plans, and to practice documentation skills. With the exponential growth of health-related data and the impact of HIT on work-life balance, it is critical for students to get early EHR skills practice and understand how EHR's work. The tEMR is a promising, scalable, flexible application to help health professional students learn about common HIT tools and issues.

Key words: electronic medical record, electronic health record, clinical learning platform, teaching, applied health information technology

LAY SUMMARY

The purpose of this paper is to provide an overview of the Regenstrief Teaching Electronic Medical Record (tEMR) , how the tEMR could be used, and how it is currently being used in health professions education. The tEMR is a copy of a real-world electronic health record (EHR), a large, pseudonymized patient database, and a population health tool designed to support curricular goals. Pseudonymized patient data is created by an automated process whereby patient identifiers are replaced with realistic pseudonyms. The tEMR has been successfully piloted at twelve health professional, public health, and health information technology schools, with over 11 800 unique student users and more than 74 000 logins, for case presentation, to develop diagnostic and therapeutic plans, and to practice documentation skills. With the exponential growth of health-related data and the impact of health information technology (HIT) on work-life balance, it is critical for students to get early EHR skills practice and understand how EHR's work. The ultimate tEMR project aim is to create tools through which our students—future educators, administrators, practice leaders, and front-line physicians—can develop enough HIT savvy to influence how HIT should be used in health care rather than HIT dictating how health care is delivered.

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BACKGROUND SIGNIFICANCE

Providing high-value health care is predominantly an information business—healthcare decisions, quality, efficiency, and outcomes depend on accessing and managing health information. The volume and growth of health-related information increasingly compel healthcare providers to understand information technology. It is estimated healthcare will generate more than 2000 exabytes (one exabyte equals one billion gigabytes) of data in 2020, up from 150 exabytes in 2013.[1]

Recently, the Health Information Technology for Economic and Clinical Health (HITECH) Act drove US hospital Electronic Health Record (EHR) implementation from under 10% in 2008 to over 95% in 2016.[2] Ironically, as EHR use grows, medical student EHR access decreased.[3] Health systems and medical schools limited learner EHR access.[4] Medical school EHR restriction is surprising since for years, educators endorsed medical student health information technology (HIT) training.[5]

Previously, educators created EHR simulators,[6] or used *sandbox* or *training/testing* environments of commercial EHR's for medical student training.[7] While EHR simulators and test environments address the gap between no EHR training and EHR exposure, these solutions fall short of robust curricular support, educational content, or providing practical, applied experience.

OBJECTIVE

To improve upon previous EHR training, the Regenstrief Institute (RI) along with the Indiana University School of Medicine (IUSM), Eskenazi Health (EH), and the American Medical Association created the Regenstrief Teaching EMR (tEMR). The tEMR provides health professional students an EHR learning environment separate from their academic health systems. The tEMR is a novel educational and assessment solution with three components: a working, educational EHR; a large, pseudonymized, patient database; and a cohort generation tool. Since 2013, the tEMR is used at 12 health profession educational institutions. Over 11,800 students have accessed the system. This article provides an overview of tEMR functions, how the tEMR could be used, and how it is currently being used in health professions education.

MATERIALS AND METHODS

System description

Electronic health record

The tEMR is a modified version of RI's Gopher, one of the first EHRs.[8] EH used Gopher as its production model EHR for inpatient and outpatient care for more than 30 years. tEMR users can perform the same core EHR tasks available through commercial EHRs including note writing, order-entry, and data review. Figures 1 and 2 are sample screenshots of tEMR's user interface (UI).

Figure 1 shows an example of the screen an instructor views. The patient and provider are identified at top left and right, respectively, with tabs for order-entry and data review. The *Instructor toolkit* and *Reports* tabs contain preceptor-only workflows. In this example, the workflows include *Release Orders*, *Note*, and *Quick Orders*. The middle of the page contains patient-specific data including medications, problems, and allergies. The interface can be customized to the user's specialty (medical, nursing, etc.) and role (instructor, student). Figure 2 is a screenshot of an order session.

Patient database

Over 12 000 real, pseudonymized, patient records are available in tEMR. Patient identifiers are protected following the *Safe Harbor* criteria. Patients' older than age 85 or with rare diseases are excluded from the tEMRdatabase. Protecting personal identifiers in the tEMR database while maintaining document readability posed a significant scaling challenge. We developed an automated pseudonymization process which redacts patient identifiers not critical to the educational process. The remaining patient identifiers are replaced with realistic pseudonyms. tEMR'spatient records include notes, test results, and orders. These patient records were selected nonrandomly from patients attending the primary care clinics of EH, an urban, public, and healthcare system serving Indianapolis.

Application hosting

tEMR is a web application requiring an Internet connection, a browser, an authorized username, and password to access the system. The RI and IU *hosts* and supports tEMR. Each client organization has a tEMR instance. An instance includes content created by each institution as well as a separate copy of the patient database. Individual institutional instances allow each organization to create content without interfering with content created at other institutions.

Data manipulation

tEMR patient record data can be supplemented, deleted, or edited to meet the curricular needs. Curriculum teams can direct which students can access the same patient record. Students can review only their own actions (eg, orders) or can be allowed to view other students' actions within the same patient's record (called shared views). Use cases for shared views include interprofessional educational (IPE) exercises.

Content delivery

tEMR includes a robust content-delivery infrastructure. Curriculum teams determine how and when content is delivered. tEMR delivers educational content through two methods. The first process is OpenInfobutton (OIB).[9] OIB provides context-sensitive links to online or locally created resources.

tEMR's second content delivery method is its clinical decision support (CDS) system. Curriculum teams can create automated, context-specific, and educational messages. Context includes both patient context (medical profiles) and user context. User-context is important for IPE as different messages, for the same patient, can be delivered to users based on their role and level of training. Like OIB, the CDS infrastructure can deliver locally created or Internet-based, multimedia content.

Evaluation

The tEMR has automated learner evaluation functionality. Through tEMR's decision support infrastructure, evaluators can deliver *just-in-time* (JIT) surveys. JIT means the survey appears immediately after the learner performs (or does not perform) an EHR action like

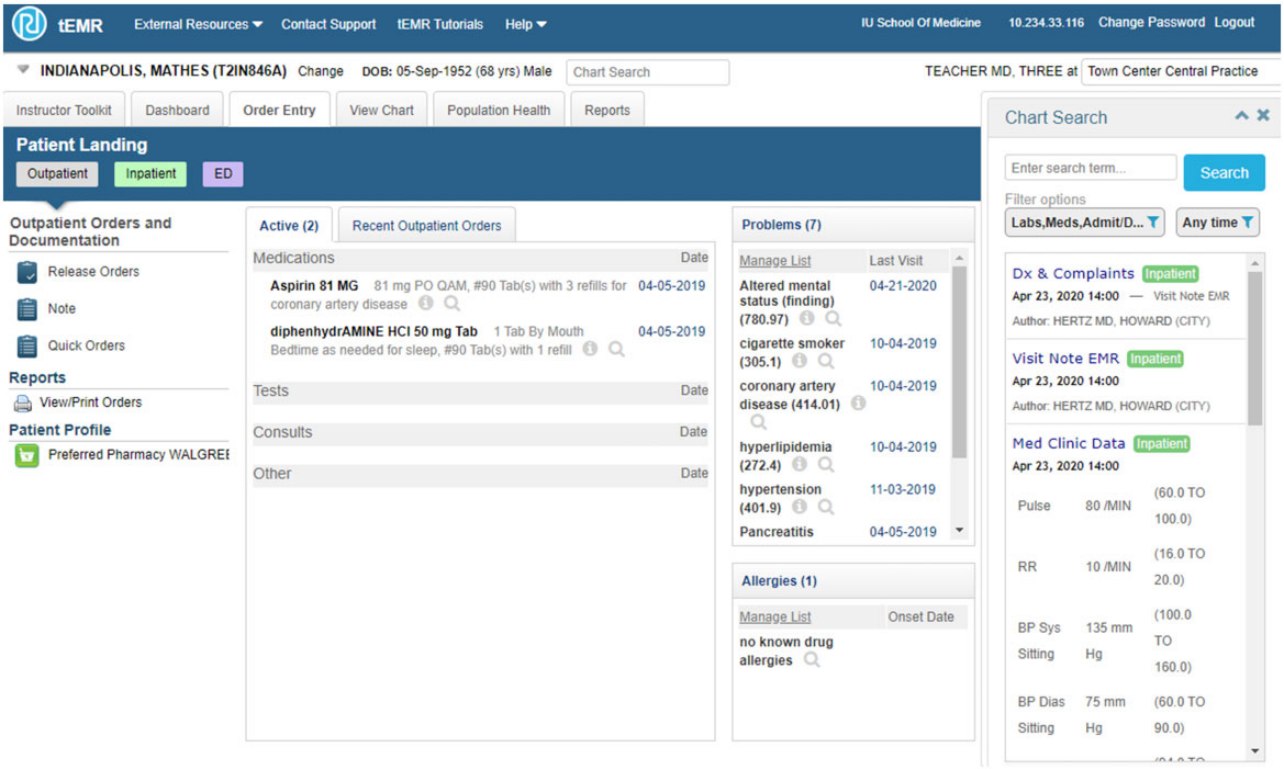

Figure 1. Screenshot of an instructor patient landing page. The landing page is the webpage that appears when a user selects a patient after logging in.

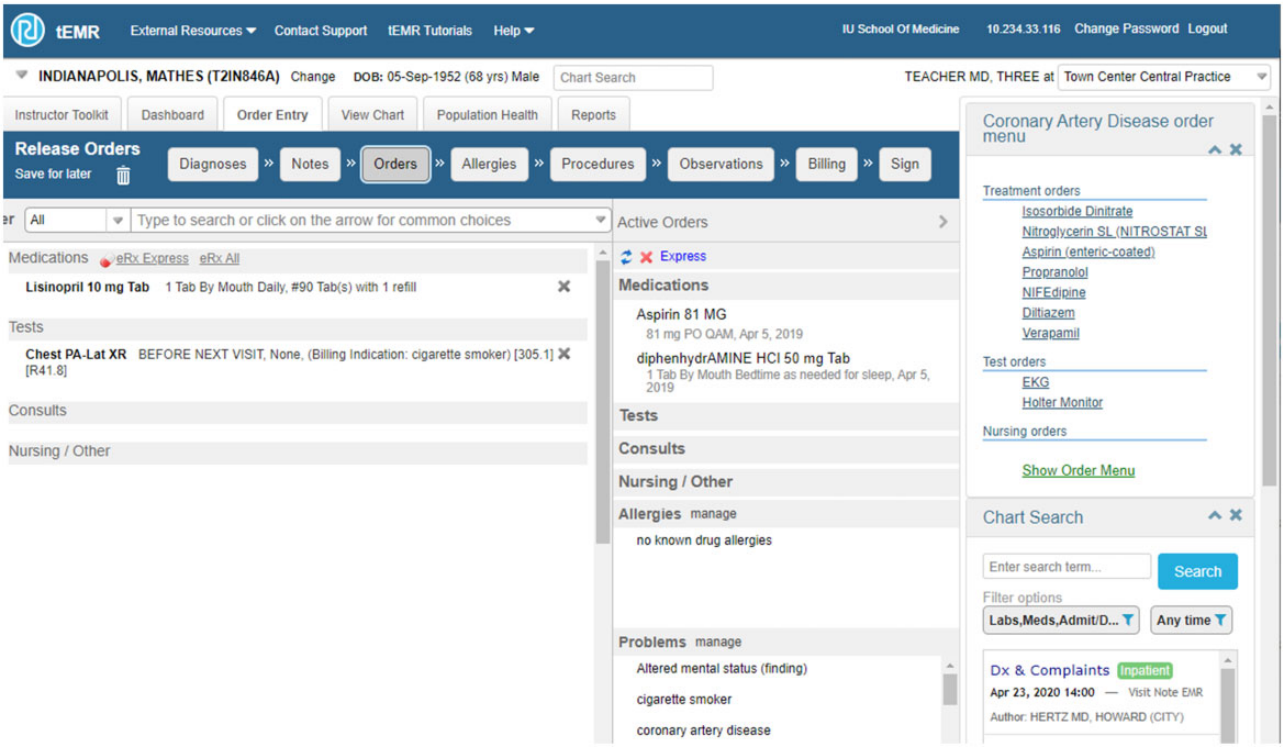

Figure 2. Screenshot of an order-entry session. The user is placing an order for erythromycin. Many of the instruction fields can be filled by picking items from drop-down menus or typing in manually.

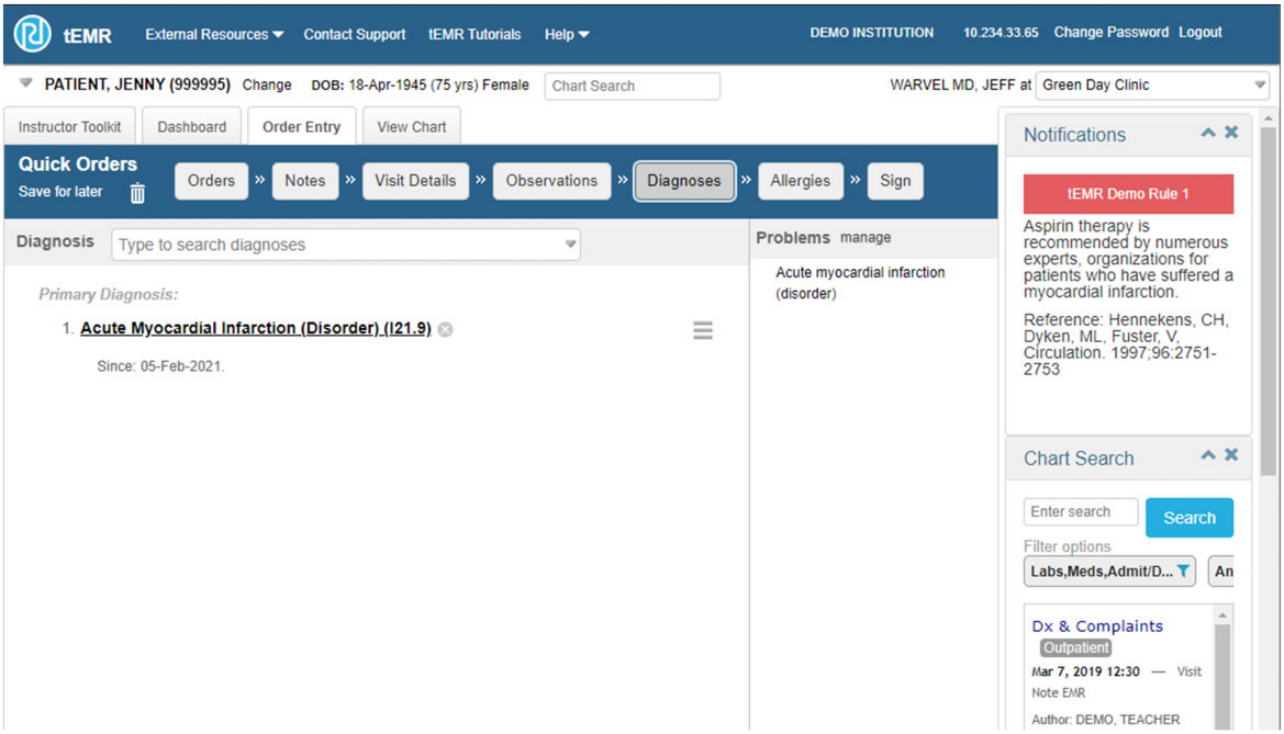

Figure 3. Screenshot of curriculum–centered alerts. This figure is an example of CDS-delivered educational messages.

entering an order. JIT surveys are designed to help evaluators discern users' thought processes while users are making decisions.

Figure 3 and Figure 4 are sample screenshots showing how tEMR's decision support alerts can be used to deliver educational and evaluation content. This example simulates an exercise in the role of aspirin therapy for patients with coronary disease showing two types of alerts. The first alert (figure 3), in the upper right background, is an example of a non-workflow interruptive alert. The second alert (figure 4) is an interruptive alert. The user must take action to make the alert *go away*. The second alert is activated only if the user does not comply with the first alert recommendations.

The tEMR also supports automated user scoring. Evaluators create a scoring rubric assigning scores to appropriate orders or diagnoses. tEMR uses the rubric to automatically assign scores to users entered orders or diagnoses. This evaluation scheme has been used for IUSM resident sessions focused on sepsis[10] and for third-year medical students in care for seniors.[11]

Population health/quality measures/value-based care

The tEMR includes a cohort creation tool. The tool is called the Regenstrief Patient List Generator (RPG). Using this tool, users can perform sophisticated queries of the tEMR database. Query criteria include patient demographics, problems/diagnoses, medications, allergies, clinical encounters, and test results.

Simultaneous chart access

A novel function of tEMR called the collaborative function, allows multiple users to work on the same patient's record simultaneously. Interprofessional teams use this collaborative function to help overcome logistical hurdles in IPE. IPE team members at geographically distinct locations can work on the same patient record at the same time (synchronously) or at different times (asynchronously). At the IUSM, IPE teams successfully used tEMR's collaborative capacity for sessions involving medical residents, advanced care nurse practitioners, and masters-level social work students.[12]

RESULTS

Use cases

For preclinical students, tEMR can be used to acclimate students to the EHR. Schools use tEMR to bring clinical relevance to preclinical courses. For clinical students, tEMR can be used for case presentation, to develop diagnostic and therapeutic plans, and practice documentation skills. At the IUSM, tEMR is used for lessons in health systems science. Health systems science, how medical care is delivered, is a third core of instruction joining the basic and clinical science cores in medical schools' curriculum. IUSM used tEMR exercises as a springboard for discussing topics such as the basics of healthcare financing and discussing inappropriate antibiotic prescribing. The University of Connecticut uses tEMR, through a family of patients followed longitudinally, to highlight the importance of social determinants of health and health inequities.

Lessons learned

Regular feedback from curricular leaders at multiple institutions implementing tEMR generated several insights.

- Using an EHR for instruction is challenging. As with clinicians, students' learning curve for their first EHR is steep and not using an EHR regularly keeps the learning curve steep.
- Students with clinical experience have fewer problems with tEMR than preclinical students. Ironically, clinical students believe EHR education should be started earlier in their education

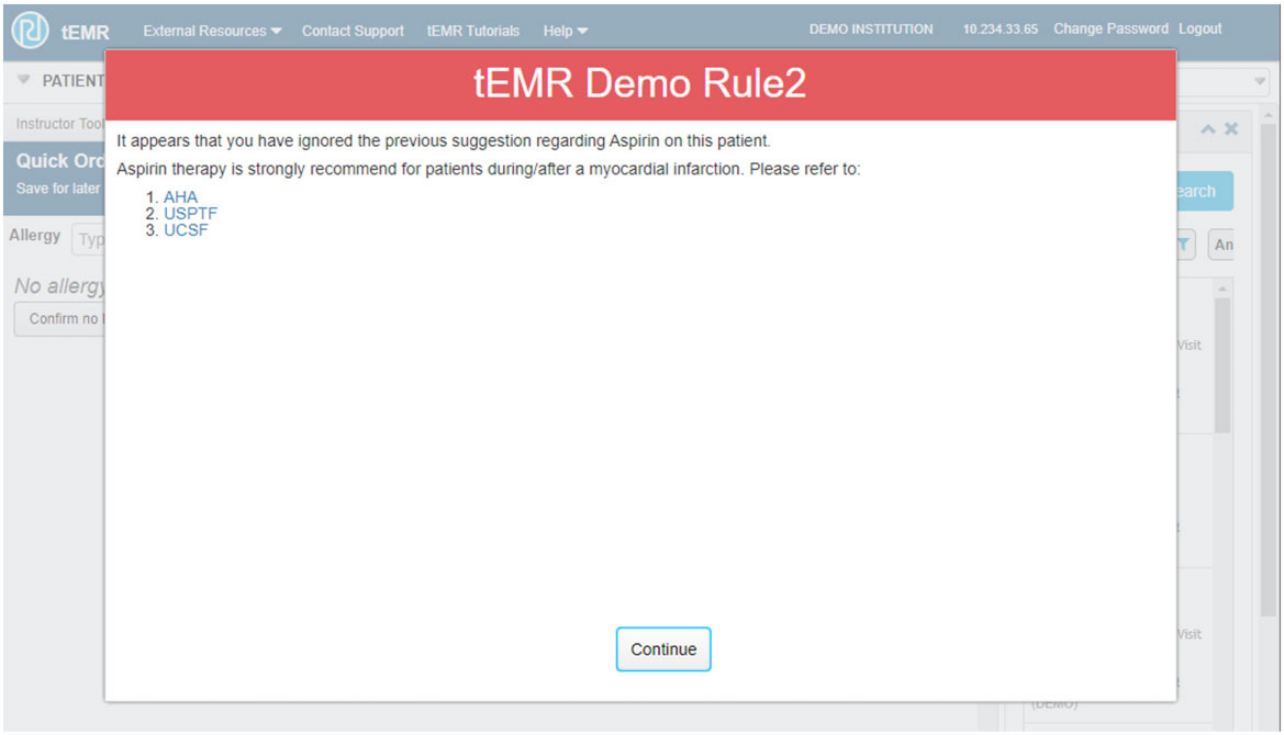

Figure 4. Screenshot of curriculumcentered alerts. This figure is an example of CDS-delivered educational message that requires the user to review and respond to the message.

whereas preclinical students feel training should be later in their education.

- Lessons other than EHR training sessions should not focus on an EHR. Lessons should focus on educational objectives using an EHR as a teaching adjunct. An EHR is a tool for delivering care not the center of care delivery.
- Many students enter medical school with EHR experience. Unfortunately, much of this previous EHR experience is not useful for physician training as these previous roles (eg, scribe) yield EHR experiences different than a physician's role.
- Clinical content needs to be adjusted to the user's level of training. Students lacking clinical experience can be distracted and frustrated by the complexity of a real patient record. However, presenting a complete complicated patient record should be regarded as an opportunity for educators to help students develop proper data heuristics.
- The tEMR offers a realistic virtual patient care experience especially welcomed during the COVID pandemic when students' access to patients in health care settings is more limited.

An overarching challenge encountered was a pervasive focus on *test preparation* rather than applied learning and preparation for real patient care within health settings utilizing EHRs. Although tEMR gives students early, hands-on experience with real clinical data from real patients, this experience is not tested by the USMLE Step 1 examination. Some students felt the interface takes too much time away from *learning the facts for test preparation* and gets in the way of the lesson. It is important to create curricular objectives to help students learn about clinical medicine while simultaneously mastering the EHR, the most important tool in the clinician's bag.

DISCUSSION

The medical education community recognizes the need to better prepare future physicians by teaching medical students core EHR/HIT competencies. When the tEMR project started, the goal was to train medical students how to use an EHR. Since the project started, general EHR use expanded and concerning EHR issues has surfaced. The two most important EHR-related issues are the exponential growth of health-related data and the impact of HIT on work-life balance. These problems underscore the need for students to get early EHR skills practice and understand how EHR's work. Numerous studies link physician burnout and professional dissatisfaction to the challenges and time demands accompanying daily EHR use. Physicians are frustrated with poor UI design as well as increased documentation and administrative burdens. Given the EHR angst experienced by practicing physicians, early exposure to core HIT competencies and appropriate preparation should aim to lessen technology-related frustration and physician burnout. Ideally, preparing the next generation of physicians for HIT challenges will graduate a cohort not only better prepared for the practice of medicine but also prepared to lead the development of user-friendly HIT systems and efficient HIT-dependent clinical workflows.

The number and variety of health profession schools using tEMR are far beyond the original anticipated medical school audience. tEMR is now used by nursing, pharmacy, occupational therapy, social worker, masters in health administration, public health, and health information technology schools. The common denominator for these organizations is learners who do not have meaningful EHR access or access to real patient data. Future research is needed to evaluate the impact on clinical student learning outcomes using tEMR compared with other commercial EHRs perhaps as part of

objective structured clinical exams or other simulated patient care scenarios requiring EHR documentation and/or order entry.

CONCLUSION

The tEMR is a promising, scalable, flexible application used by health professional schools to help students learn about common HIT tools and issues. Since the tEMR code is under local control, the project can create functionality to support the educational mission likely not possible in commercial EHR's. The ultimate tEMR project aim is not to train informaticians but to create tools through which our students—future educators, administrators, practice leaders, and frontline physicians, can develop enough HIT savvy to influence how HIT should be used in health care rather than HIT dictating how health care is delivered.

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AUTHOR CONTRIBUTIONS

Authors contributed to the concept and design (BYT, WMT, BWM, DKL), acquisition of data (BYT, WMT, and DKL), preparation of manuscript (BYT, WMT, and DKL), critical revision of the manuscript for important intellectual content (BYT, WMT, PJE, BWM, JW, DKL), obtained funding (BYT, WMT, PJE, DKL), and contributed to the study supervision (BYT, JW, DKL).

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CONFLICT OF INTEREST STATEMENT

None declared.

PREVIOUS PRESENTATIONS

Takesue, B., Finnell, J. Duke J. An EMR designed for teaching and educational research based on the Regenstrief Institute's Gopher System. AMIA 2014 Ann Symposium, November 2014.

DATA AVAILABILITY

The data underlying this article will be shared on reasonable request to the corresponding author.

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