Clinical Informatics Training During Emergency Medicine Residency: The University of Michigan Experience

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ABSTRACT

Clinical informatics (CI) is a rich field with longstanding ties to resident education in many clinical specialties, although a historic gap persists in emergency medicine. To address this gap, we developed a CI track to facilitate advanced training for senior residents at our 4-year emergency medicine residency. We piloted an affordable project-based approach with strong ties to operational leadership at our institution and describe specific projects and their outcomes. Given the relatively low cost, departmental benefit, and unique educational value, we believe that our model is generalizable to many emergency medicine residencies. We present a pathway to defining a formal curriculum using Kern's framework.

NEED FOR INNOVATION

Physicians use electronic health records (EHRs) nearly twice as often as they interact face to face with patients in both the emergency department (ED)[1] and other clinical environments.[2–4] EHRs enhance care overall,[5] but EHR usability has been implicated in patient safety events,[6–8] physician burnout,[9–11] and increased task-switching in the ED.[12] Despite this complexity, EHRs will remain an essential component of the health care environment in the future. Therefore, just as we train our residents to be experts in airway management and central venous catheterization to minimize adverse events,[13,14] we need to train them longitudinally in the use and optimization of EHRs and other clinical informatics (CI) systems.

In this article, we conduct a historical review of residency CI education in the United States followed by a description of our experience developing an informatics track within our 4-year training program for senior residents interested in developing advanced informatics skills. Finally, we present a possible pathway other programs could use to define a formal curriculum using Kern's framework.[15]

BACKGROUND: RESIDENT INFORMATICS EDUCATION IN THE UNITED STATES

"Clinical informatics is not simply 'computers in medicine' but rather is a body of knowledge, methods, and

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theories that focus on the effective use of information and knowledge to improve the quality, safety, and cost-effectiveness of patient care as well as the health of both individuals and populations."[16] Most informatics training in the United States is directed toward fellowship-level learners. Accreditation Council of Graduate Medical Education (ACGME)-sponsored fellowships in CI have been in place since 2014 with a goal of training board-certified informaticists from varied clinical specialties. As of 2020, there are 43 ACGME-accredited CI fellowships listed by the American Medical Informatics Association (AMIA).[17] AMIA has also sponsored both generic and emergency medicine (EM)–specific survey courses of CI ("AMIA 10 × 10"), but these courses have been designed for physicians who were already in practice, rather than residents.[18]

Residency informatics curricula emerged during the 1990s when general computing was more foreign to the average user, with examples in internal medicine,[19] pathology,[20–23] pediatrics,[24] psychiatry,[25] and radiology.[26,27] Early curricula, especially in pathology, focused on basic laboratory codes, hardware, decision support, and data management.

A program from the University of California, Los Angeles (UCLA) provides the most in-depth modern example of general CI training during residency training, where trainees from multiple disciplines underwent longitudinal CI training throughout their residency.[28] The program successfully developed interest, satisfied graduates, and facilitated project completion producing improvements to their health care system at a pragmatic cost. However, only a small subset (4.3%) of their trainees represented emergency medicine, and the efforts were not driven by the ED's needs. Similarly, there are few requirements within EM residency curricula for expertise in informatics-related domains.[29] To date, the authors are unaware of any published experiences of EM residency–based CI training. Therefore, in this article, we present our experience piloting a CI track within our residency.

EM RESIDENT INVOLVEMENT IN CI: MOTIVATION AND JUSTIFICATION

Many areas of focus within CI are relevant to EM, including clinical decision support,[30] usability testing,[31] clinical summarization,[32] computerized physician order entry,[33] and predictive analytics.[34,35] Innovation in any of these areas requires clinicians who deeply understand clinical workflows and who can inspire change at a grassroots level. As the proverbial "boots on the ground," resident physicians are keenly aware of clinical workflow inefficiencies and workarounds as well as the strengths and limitations of their health systems' EHRs. We believe that this perspective positions residents to serve as effective translators between clinical and informatics domains. Furthermore, residents have both educational requirements for involvement in quality improvement (QI) projects[36,37] and demonstrated abilities to effect change through such projects.[38] As examples, resident-led QI projects have created sustained decreases in ED boarding times,[39] resulted in safer inpatient handoff practices,[40] and improved pneumococcal vaccination rates in older admitted adults.[41] Given these factors, we theorized that resident participation in an EM informatics curriculum would provide unique educational and service-based opportunities.

THE RESIDENT PHYSICIAN BUILD TEAM: OBJECTIVES AND DEVELOPMENT PROCESS

Our team developed in a grassroots manner after the first author (senior EM resident) sought out the last author (associate chief medical informatics officer; board-certified in EM and CI) seeking opportunities in EM informatics. After examining possible tracks, we identified two likely populations seeking advanced informatics training during residency: those seeking advanced training as part of a career in operations or research and those seeking a formal informatics fellowship and CI board certification.

We examined several options including formal curricula using classic textbooks,[42] standardized national CI courses,[18] and vendor-based EHR optimization training.[43,44] We balanced the schedule and cost-related impacts of these options with the baseline requirements of an already-busy EM residency schedule. Ultimately, vendor-specific Epic Physician Builder training through our EHR vendor (Epic Systems Corporation, Verona, WI) provided residents with concrete skill development that could be deployed rapidly, at minimal cost, and with minimal impact on clinical scheduling, which were important factors during residency training. For these reasons, we focused our program on the development and use of these hands-on EHR optimization skills.

Epic training programs are free; however, travel costs and protected time for skill development required consideration. Costs were addressed through application for local residency development grants

and, given our geographic location in Southeast Michigan, amounted to roughly $2000 total, which provided travel and lodging for two separate 4-day visits to the training site in Wisconsin. Protected time was facilitated using shift clustering in consultation with program leadership in advance of training. Since 2017, we have had six residents complete physician builder training within our residency using this process.

After training, residents became familiar with the governance, design, and optimization of ED information systems by joining regular meetings with ED operations and informatics leadership. Residents were supervised by our lead EM EHR analyst (S.B.), who was a key partner in developing guidelines for project design, project management, and supervision of build activities. Partnering with a health information technology expert allowed residents to contribute productively to operational needs in a safe and supervised manner. Resident projects were selected based on informal assessment of need within the ED based on conversations with faculty, residents, ED leadership, and physician assistants. Residents were encouraged to evaluate their projects and present their results at national meetings. Program leadership facilitated this goal through scheduling and financial support.

OUTCOMES

Outcomes of the curriculum include involvement in projects, the outcomes of the projects themselves, and the career preparation resulting from participation in the track. To date, CI track residents have completed projects in several domains including order set generation and analysis, documentation workflows, clinical decision support, and user interface improvements. All projects underwent review by ED operational and EHR analyst teams prior to build, testing, or deployment, and some underwent more in-depth evaluation (discussed below). Table 1 lists specific projects.

Table 1
Resident informatics Contributions During the First Three Years of the Michigan CI Track

Activity	Specific Projects
Order set generation and analysis	- Order sets to facilitate paracentesis (with formal user experience evaluation), arthrocentesis, thoracentesis - Order sets to help manage rare and high-risk situations including acute liver failure, overdoses requiring lipid emulsion therapy or high-dose insulin, leukostasis, subarachnoid hemorrhage, aortic dissection, ventricular assist device management, and novel coronavirus (COVID-19) infection
Documentation workflows	- Ultrasound-guided nerve block documentation workflow with documentation templates - Pulmonary ultrasound workflow with documentation templates - Updated and streamlined ultrasound procedure documentation (thoracentesis, arthrocentesis, paracentesis, central venous catheter, arterial catheter, incision and drainage, lumbar puncture)
Clinical decision support	- Designed, built, and generated training materials for clinical decision support system facilitating the use of the Canadian Head CT Rule in minor head trauma based on local insurance-based incentive measures with a timeline to pursue similar approaches for improving adherence to pulmonary embolism diagnostic pathways and pediatric chest x-ray pathways
User interface improvements	- Improved user interface and workflows for emergent laboratory, imaging, and consult ordering - Participated in ED trackboard color scheme design using user-centered principles

CI = clinical informatics.

Detailed Project Examples

We present in more detail two interventions and their outcomes: an order set facilitating paracentesis and a clinical decision support tool used to improve adherence to head CT ordering guidelines. The paracentesis order set project provided both operational value for our ED as well as educational and academic productivity for the involved resident. Informal discussion with residents revealed the need for a paracentesis order set, which did not previously exist. Prior workflow was time-consuming and inefficient, requiring users to access multiple EHR screens for point-of-care ultrasound, laboratory, and local anesthetic orders. Clinical guidelines were evaluated, paper prototypes were generated, and institutional review board approval was obtained. The order set was then built in the EHR (see Figure 1). Using Morae (Techsmith Corporation, Okemos, MI), we observed and timed 17 EM clinicians performing scripted tasks facilitating the performance of paracentesis and ascites analysis in a simulated EHR environment. The same tasks were performed first without and then with the order set.

We observed clinicians from the following levels of training: attending (3), PGY-1 (3), PGY 2-3 (4), PGY 4 (3), physician assistant (3), and off-service internal medicine resident (1). Order consistency with clinical

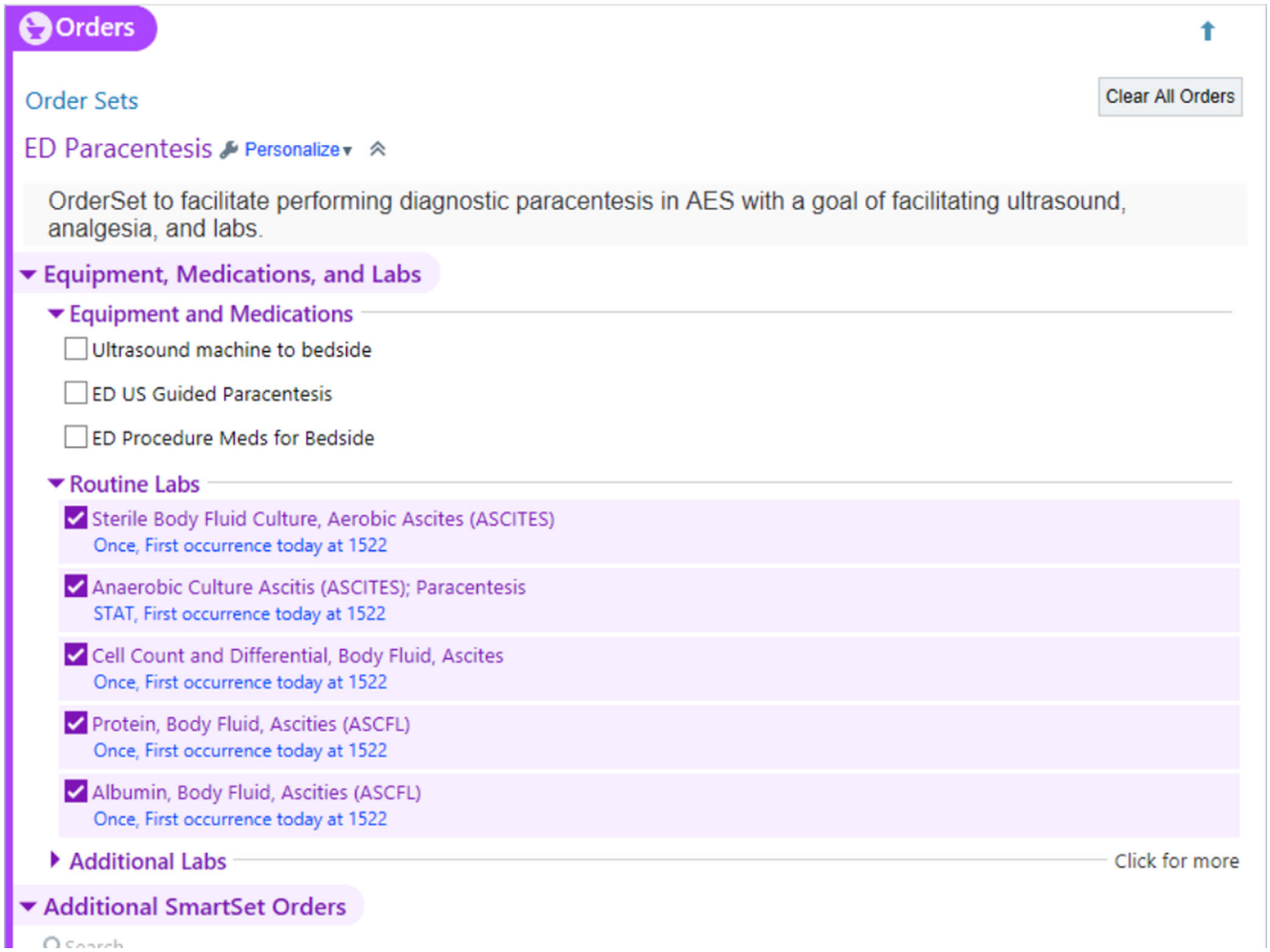

Figure 1. The final order set after performing usability evaluation and incorporating feedback. (Proprietary user interface components © 2020 Epic Systems Corporation. Reproduced with permission and under Office of the National Coordinator for Health Information Technology (ONC) Common Rule for Usability.)

guidelines, efficiency of task completion, and provider ease-of-entry were extracted and analyzed in aggregate by level of training. Providers' orders were reported as inconsistent with clinical guidelines if the provider required guideline consultation during order entry or the provider acknowledged they had forgotten a test after seeing the order set. Consistency with guidelines ranged from 0% in interns to 100% in faculty. Overall, clinicians were consistent with guidelines 29% of the time. On average, providers took 3.57 minutes without the order set and 0.85 minutes with the order set. Efficiency gains were greatest in interns and off-service residents. Ease-of-entry scores, reported as a Likert scale from 1 (very easy) to 5 (very hard), improved by a mean of 1.71 points with addition of the order set. The results of this analysis led to both ongoing support for the program internally as well as a poster presentation at the Council of Residency Directors in Emergency Medicine 2019 Academic Assembly.[45]

The head CT project provided a unique experience for residents to engage in clinical decision support development. The Michigan Emergency Department Improvement Collaborative (MEDIC),[46] a Blue Cross Blue Shield of Michigan and Blue Care Network–supported collaborative quality initiative throughout the State of Michigan, sought to improve physician adherence to head CT ordering guidelines for adults with minor head trauma as defined by the Canadian Head CT Rule.[47] A statewide dashboard provided metrics for hospitals and individual clinicians, and value-based reimbursement (VBR) incentives from insurers encouraged improvement. Trained abstractors determined ultimate adherence with the decision rule. In consultation with the department operations leadership and MEDIC Clinical Champions, residents in the informatics track designed, built, and tested an interruptive clinical decision support tool to facilitate completion of the Canadian Head CT rule at the time of CT ordering in the EHR. Additionally, they produced

Table 2
Potential Curricular Framework Using Kern's Six-step Approach to Curricular Development

Stage	Key Steps
1. Problem identification and general needs assessment	Given the substantial role EHRs play in clinical care, physician involvement in optimization is critical. Residents receive little training in informatics and are rarely involved in EHR optimization but are uniquely suited to help solve this problem given their understanding of clinical workflows, EHR strengths and limitations, and potential as change-makers through QI initiatives. Current approach: EM residents occasionally seek out advanced training in CI without any formal structure or track. Ideal approach: A structured program would provide education in CI including hands-on skill development, basic fluency in informatics standards, governance, and project management. A project-centered curriculum would allow resident contributions to operational initiatives and provide opportunities to design, implement, and evaluate CI tools.
2. Targeted needs assessment	Learners: Senior EM residents interested in CI Learning environment: CI track Specific needs: Depending on career goals, could mirror AMIA core content for fellowship[48–50] or focus on operational-specific skills. Real-world certification, such as Epic Physician Builder certification, is necessary to allow hands-on work.
3. Goals and objectives	Broad goals: a. Provide early exposure to CI and, if in line with long-term goals, prepare residents for CI fellowship or CI-related career specialization. Provide industry standard theoretical and hands-on CI training.
4. Educational strategies	a. Early recruitment to allow time for fundraising, scheduling, and training b. Biweekly meeting to discuss projects and techniques c. Biweekly reading with small group discussion among track members based on AMIA fellowship core competencies d. Expectation of scholarly project resulting in national presentation or publication e. Expectation of local QI project resulting in live build with subsequent evaluation (usability, performance, or both)
5. Implementation	- Begin structured approach with senior residents during last quarter of prior year - Expand available enrollment based on program interest
6. Evaluation and feedback	a. Quarterly progress reports completed by each resident and reviewed with program supervisor to ensure goals are met and projects are under way b. Annual survey of participating residents to evaluate attitudes surrounding the success of the program c. Measure number of participating residents who complete a QI project, successfully present CI-based work at a national conference or through a journal, accomplish hiring goals at conclusion of residency

CI = clinical informatics; EHR = electronic health record; QI = quality improvement.

educational materials for clinicians to understand its use. Deployment of the tool resulted in an initial improvement of adherence from 38.1% to 69% and a year-over-year improvement from 49.5% (2018) to 57.9% (2019). More rigorous study will be needed to evaluate the significance and longevity of this effect. This project not only allowed resident participants to directly impact clinical care, but also provided an opportunity to develop relationships with operational leaders as well as led to direct improvement in department VBR through the MEDIC and Blue Cross Blue Shield collaborative. This endeavor clearly demonstrated the wide-ranging impacts that can be obtained through resident contributions to EM informatics.

Career Preparation

At present, two participants have graduated from the program: one was accepted to an ACGME-accredited CI fellowship and the other accepted a community position with financial support for EHR optimization and physician builder work.

REFLECTIVE DISCUSSION: LESSONS LEARNED AND FUTURE DIRECTIONS

Overall, we consider our resident informatics track to be a success based on our residents' contributions to our department as well as the skills, experience, and career opportunities derived from participation in the program. We acknowledge, however, that the absence of a formal, longitudinal curriculum and structured evaluation plan represents a limitation in the

scalability of our program in its current state. Given this lesson, we recommend that residencies developing similar programs consider using a framework like Kern's approach to curriculum development.[15] The most notable feature from this framework missing from our own experience with curriculum generation is the prominence of a formal needs assessment, which we would strongly recommend before starting a new program. We provide an example using this framework in Table 2.

We believe that our experience implementing an EM-based CI track suggests benefits both to resident education and to departmental service by involving EM residents in the optimization of the EHR and in the design and implementation of new features. It also outlines a pathway for the development of advanced expertise among a group of motivated senior residents. A project-based core is essential to any advanced pathway and will require local customization based on learner and departmental needs. Existing CI courses could guide detailed curriculum development for advanced learners. Several example courses include:

- AMIA 10 × 10 courses (including an EM-specific option);[18]
- CI fellowship curriculum requirements[48–50]
- Advanced courses offered by EHR companies

Additionally, there are several organizations within EM where EM residents can get involved at a national level:

- Emergency Medicine Residents Association (EMRA) Informatics Committee;
- Society for Academic Emergency Medicine (SAEM) Academic Informatics Interest Group;
- American College of Emergency Physicians (ACEP) Informatics Section.

CONCLUSION

Our experience building an informatics track for senior emergency medicine residents demonstrates the educational and service-based benefits of providing advanced informatics training to emergency medicine residents. Our program was affordable with close connections to clinical care and operational needs, but flexible enough to prepare learners destined for both academic and community-based careers. We believe that these features make our approach generalizable to many programs. Future work includes formal curriculum development using an established framework. Furthermore, there may be opportunities for more generalized informatics training for all emergency medicine residents, instead of just self-selected senior residents.

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