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An Introduction to Clinical Informatics for Early Medical Learners Using Colorectal Cancer Screening

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Abstract

Introduction: Clinical informatics is an important component of the AMA-endorsed third pillar of undergraduate medical education, health systems science. Discrete educational opportunities for clinical informatics and health systems science among early learners are lacking in medical school curricula. **Methods:** We developed and evaluated a multistep, 2.5-hour activity during the gastroenterology module to introduce these topics to preclerkship medical students. A didactic session introducing clinical informatics and clinical decision support and reviewing health promotion and screening concepts was followed by small-group activities. Students worked through a series of exercises culminating in the generation of a clinical decision support tool based on the United States Preventive Services Task Force (USPSTF) colorectal cancer screening recommendations. **Results:** Between 2022 and 2023, 326 first-year medical students participated in this workshop. Feedback was predictably mixed. In 2022, 88% of postclass survey respondents confirmed having a better clinical informatics understanding after the workshop. In 2023, students reported a statistically significant increase in their self-reported understanding of the role of clinical informatics, clinical decision support, and USPSTF colorectal cancer recommendations. **Discussion:** Clinical decision support is a viable pathway for introduction of clinical informatics, health systems science, and public health/prevention topics. Our educational approach offers an interactive introduction to this group of topics that can benefit future physicians. While colon cancer provides a robust option for the clinical situation, this activity could be modified to fit into many different clinical scenarios, allowing for interdisciplinary education during either undergraduate or graduate medical education.

Keywords

Colon Cancer, Gastroenterology, Health Systems, Informatics/Health IT, Population Health, Preventive Medicine, Professional Identity Formation, Systems-Based Practice

Educational Objectives

By the end of this activity, learners will be able to:

1. Define clinical informatics and its role in the delivery of health care.
2. Identify the function of clinical decision support in the context of clinical workflows.
3. Apply clinical decision support to United States Preventive Services Task Force screening guidelines for colorectal cancer screening.
4. Identify at least two strengths and one limitation of clinical decision support.

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Introduction

Traditional medical education has frequently been divided into two parts, the basic sciences and the clinical sciences. More recent medical education frameworks add health systems science (HSS), including clinical informatics, as undergraduate medical education's third pillar.[1] Clinical informatics is the application of information science and information technology to the delivery of health care.[2] Clinical decision support is an important component of clinical informatics competency, and early exposure to this topic is advocated.[3] Preventive medicine is another important, relevant topic that is not always well covered during the basic science curriculum.[4] Finding time in the already packed academic curriculum to cover additional topics can be challenging.

While others have generated educational activities based on applying United States Preventive Services Task Force (USPSTF) guidelines to individual patients[5,6] or have introduced the broader topic of colon cancer screening to preclinical students,[7]

our activity directs most attention to clinical informatics while allowing for extension into the more clinical or basic science considerations of the topic. We coupled the introductory didactic session with a series of building exercises to provide repeat exposure to the covered topics. Our hypothesis was that a hands-on, interactive activity would be more interesting to the students and faculty and would allow for more flexibility given the significant variation in prior experience with such topics as population health, data quality, colorectal cancer (CRC) screening, clinical decision support, and coding. In addition, we postulated that the culminating activity (in which each student had a generated list of patients with them as the responsible physician) could progress their professional identity formation.

This innovative and interactive learning activity formally introduced both overarching clinical informatics concepts and clinical decision support to first-year medical students. Simultaneously, it introduced them to preventive health care/cancer screening and could be used to segue into the basic science and clinical science topics related to CRC and CRC screening. Part of the activity included small-group work that allowed students to collaborate with, and learn from, their more knowledgeable peers and/or group facilitators as they worked through a progressive series of exercises. This educational activity's capstone was the application of a student-generated clinical decision support tool for CRC screening among fictional empaneled patients.

Methods

This 2.5-hour educational activity took place during the gastroenterology module in the later part of the first year of medical school. The setting was a large, open conference area with tables for small groups. The room was equipped with computer access, projection screens, and Wi-Fi. Students were expected to bring a laptop or tablet device, though up to three students could share one screen without hindering the process. We utilized a series of tools within the Google Workspace for the session. Google Forms, a data gathering tool, Google Jamboard, a digital interactive whiteboard, and Google Sheets, an online spreadsheet program, were freely available to Google users and facilitated easy sharing with others. Other online tools with similar functionality could be used in substitution. The students received prework material (Appendices A and B) and attended a pair of presentations (Appendix C) before the activity. The prereads and presentations provided an introduction to clinical informatics and an overview of general screening concepts. Additionally, the presentations introduced the USPSTF recommendations with a focus on CRC screening.[5] Included in the lecture was a data quality exercise that consisted of intentionally unclear instructions to complete an open-ended Google Form. The results were collated during the lecture and revisited at the end of the lecture, before the small-group activities, to make the point that even the best informatics systems cannot provide maximum benefit if the underlying data is inaccurate or unstructured. Learners then undertook a series of three activities using paper cards (Appendix D), Google Jamboard (Appendices E and F), and Google Sheets (Appendix G).

Students were divided into 28 groups of six to seven students. The 28 groups were organized into four sets of seven tables, labeled A1-A7, B1-B7, and so on.

Warm-up Activity

The warm-up activity used a static Jamboard (Appendix E) to take the students through a stepwise process of identifying crates of fruit that should be recalled. Each group received 18 fruit crate cards (Appendix C) and proceeded through the Jamboard to identify and separate the recalled fruit crates (cards) from those not at risk. The provided PowerPoint file (Appendix D) was printed and cut out before the activity.

On the surface this was a simple read-and-follow-directions exercise, but it had several different goals. Through the exercise, the students gained familiarity with other small-group members and the functionality and navigation of Jamboard. One particular step involved searching for crates with a specific produce code number. This process was directly analogous to searching an electronic health record for a specific diagnostic or procedure code. This exact format was used in the second activity in which students applied the USPSTF CRC screening guidelines and determined the clinical informatics step to categorize patients correctly.

USPSTF Guideline Interpretation

Using the warm-up activity as a template, student groups considered one facet of CRC screening and how a clinical decision support tool would use that parameter. Each slide on the new Jamboard template (Appendix F) presented a single, different, relevant parameter for consideration (age, exclusion criteria, fecal occult blood test, stool DNA fecal immunochemical tests, colonoscopy, virtual colonography, and flexible sigmoidoscopy). Each small group considered a single parameter, with seven different small groups working from the same Jamboard on different slides. As demonstrated in the static warm-up activity Jamboard, students completed a three-step process for their parameter. First, they described in plain language what the USPSTF recommendation advised for the

assigned parameter: for example, "A normal colonoscopy satisfies the screening recommendation for 10 years." Second, the group identified the component of the electronic health record that would be used to categorize patients. From the preread material and lecture, we expected the students to know that various computer health codes existed and came in a few different forms. We did not expect students to identify specific codes by number but did want them to understand that International Classification of Diseases (ICD) codes[8] provided information about diagnoses and some procedures while Common Procedural Terminology (CPT)[9] and Healthcare Common Procedure Coding System (HCPCS)[10] codes provided information about procedures or laboratory tests. Finally, the group created a pseudocode statement that consolidated the two previous steps into an easy-to-follow guide for a computer programmer (or, in this case, their fellow students): for example, "A CPT code for colonoscopy in the past 10 years would satisfy this trigger."

Clinical Decision Support

In the third stage, each individual was asked to use all seven slides on their row's Jamboard to program a clinical decision support tool for CRC screening. Each student downloaded their own version of a prepared Google Sheet (Appendix G). This sheet contained 1,800 randomly generated patients with basic demographic information and relevant CRC screening history. Each line also included one of the students' names as the physician for this patient. This large patient list was intended to be overwhelming and to demonstrate the difficulty in trying to address this type of question for every patient without informatics support. The second tab of the spreadsheet was coded with drop-down menus that allowed the students to reference their group's Jamboard and then select triggers and satisfiers for their spreadsheet: for example, "Colonoscopy $\leq$ 10 years." Two methods of direct feedback were provided in the spreadsheet. First, the main database had a field that indicated if the patient was flagged as due for CRC screening based on the parameters set by the student. Correctly categorized patient flags were conditionally formatted with green backgrounds and incorrectly categorized flags with red backgrounds. Finally, a third tab of the spreadsheet provided a dashboard of pre- and postimplementation of the clinical decision support tool (a population health metric) and a list of patients sorted by screening status (a patient registry). The patient list was filterable by selecting the assigned physician from a drop-down menu, so each student could select their own name and see a list of approximately 10 patients who were under their care, about half of whom needed CRC screening. To end the activity, the group's attention was drawn back to the main screens in the classroom, and the full function of the spreadsheet was demonstrated again for everyone. We emphasized the change from an undifferentiated list of 1,800 patients to an actionable list of five patients who had been assigned to one person and were due for CRC screening.

Facilitator Training

In an ideal setting, each small group could have a dedicated facilitator. Due to faculty limitations, we had two small groups per preceptor, which made the activity somewhat more student-led but still provided the groups with guidance and assistance when needed. Facilitators received access to all appendices, including a faculty orientation PowerPoint presentation (Appendix H), before the activities.

Variation in 2023

The session in year two was substantially the same, with three notable changes. The warm-up activity was skipped, and a brief discussion of artificial intelligence was inserted. Each table worked on its own Jamboard to complete all the parameters rather than focus on just one parameter and share a Jamboard along a row.

Results

2022

One hundred sixty-one first-year medical students participated in this activity in its first year. Fourteen faculty served as preceptors for the small-group activity, working with two adjacent tables. A separate facilitator ran a virtual version of the activity for students unable to participate in person.

Thirty percent (48 of 161) of the students responded to a feedback request, providing both quantitative data and written comments. Feedback was predictably mixed, as is commonly seen with HSS topics. Figure 1 shows the overall rating of the session. Approximately equal numbers of students rated the activity above or below average.

Figure 2 contains paired quotes from different students who all attended the same educational activity.

In the first year of implementation, 88% of respondents stated that they had a better understanding of clinical informatics after the session.

2023

One hundred sixty-five first-year medical students participated in this activity in its second year. Fifteen faculty served as preceptors for the small-group activity, working with two adjacent tables. One hundred fifty-nine students completed a presession

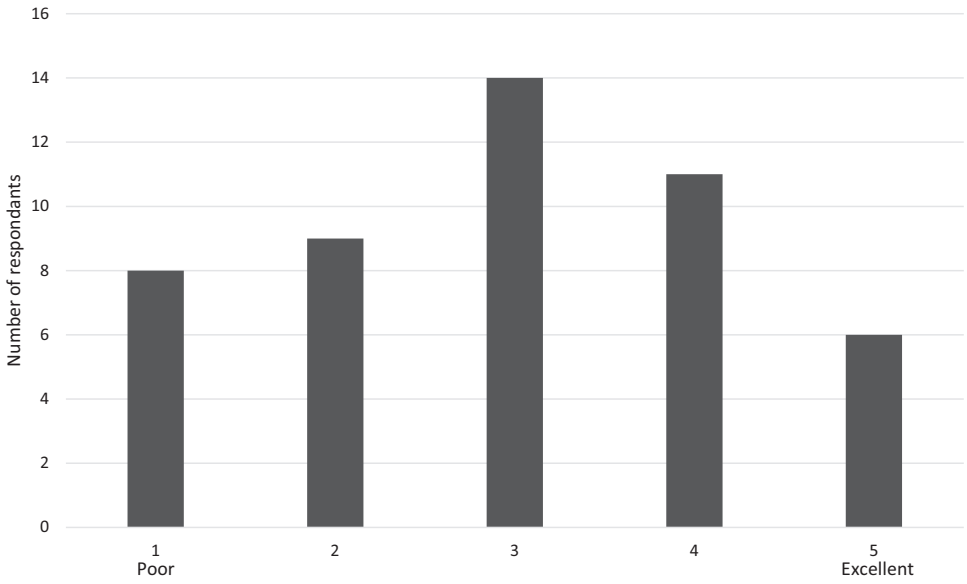

Figure 1. Student ratings of overall opinion after attending the 2022 clinical informatics session.

self-evaluation. Thirty-two percent (52 of 165) completed a postsession evaluation containing the same questions and the same 5-point rating scale.

The pre/post self-evaluation questions and mean rating are shown in the Table. There was a statistically significant increase in postsession self-assessment score on all questions (unpaired *t* test).

Discussion

This combination of a didactic session with a hands-on, interactive, progressive activity allows the introduction of several potentially underrepresented topics early in medical school education. It provides an opportunity to highlight the importance of informatics, including data quality and clinical decision support, along with disease prevention and screening. In addition, it offers individual, small-group, and large-group interactions that may facilitate community building and engagement. Professional identity formation for medical students is an important evolution that occurs throughout medical school and through postgraduate training. Identifying the students present by name in the completed spreadsheet with a list of fictional patients under their care has the potential to be a powerful early step in the formation of their professional identity.

Gonzalo and Ogrinc have noted that student feedback on HSS educational topics is frequently mixed.[11] Our experience was similar, as highlighted in Figure 2, which shows the opposing opinions and conflicting recommendations for changes for this session. Consistent with these diametrically opposed comments, approximately equal numbers of students rated this activity above or below average in 2022. We are encouraged by the number of students who indicated they had a better understanding of informatics after the session even though some of them would have also rated the session below average.

This kind of feedback complicates decision-making about ways to improve the educational activity. In the second iteration, we eliminated the warm-up activity, which led to fewer comments that the session was too basic but more comments that students

"I think the large group lecture was nice, but it still felt like it needed to be boiled down into simpler terms."	"The speeches were cursory and revealed little that could not be inferred by common sense."
"I am not a computer programmer, nor will I ever be."	"I think we could have a more elaborate activity, as many of us have coding experience."
"I really liked the small group activity. . . ."	"I don't think the activity was a valuable use of my time."
"Great info, will probably be increasingly important as time goes on."	"This session did not feel applicable."

Figure 2. Contrasting quotes from 2022 student attendees.

Table. Mean Difference in Scores Among Participants

Question	Mean Score[a]		Mean Difference (95% CI)[b]	*p*[b]
	Baseline (*N* = 159)	Postsession (*N* = 52)		
How well do you understand the role clinical informaticians play in health care?	2.3	3.9	1.6 (1.2-1.9)	<.001
How well do you understand how clinical decision support systems can promote quality and patient safety?	2.5	3.9	1.4 (1.0-1.7)	<.001
How familiar are you with interpreting USPSTF recommendations?	1.5	4.0	2.5 (2.2-2.7)	<.001
How confident are you in applying USPSTF recommendations regarding colorectal cancer screening?	1.6	4.0	2.5 (2.2-2.7)	<.001

Abbreviations: CI, confidence interval; USPSTF, United States Preventive Services Task Force.
[a]Rated on a 5-point scale (1 = *Very Low*, 5 = *Very High*).
[b]Unpaired *t* test.

wanted clearer directions on what to do with the Jamboard. We believe the warm-up activity provides a model to follow and is presumably more beneficial for students with less experience with these topics or tools. More robust data were collected in 2023, and students self-assessed that they had gained familiarity with and understanding of CI, clinical decision support, and USPTF and CRC screening.

While HSS coursework evolves from its infancy, educators and teaching methods can build upon existing student HSS interests, such as health disparities of preventive services. Perceived lack of physician empowerment to effect health system change remains a barrier that requires broader transformation of medical education and clinical practice to develop the HSS competencies required to deliver safe and high-quality care. Our session aims to merge these topics in a way that builds on the varying strengths of a diverse student pool while giving all students exposure to areas in which they have less experience. Additionally, clinical science coursework facilitates the formation of students' professional identities as systems-minded physicians. Learning activities such as ours afford an opportunity for students to reflect on systems experiences and quality improvement, which are increasingly valued during the transition to graduate medical education.

Our project has several limitations. It has been formally presented to two classes of medical students on a campus with sufficient technological resources. Assessment of this educational activity has been limited to the learning domain of Kirkpatrick's pyramid.[12] Long-term changes in knowledge, attitude, or skills have not been assessed. The optimal timing for introduction of these topics has not been determined. Given the active nature of this learning activity and its relevance to direct patient care, the small-group activities may promote learner engagement and receptivity after students have directly experienced challenges of health care delivery during their clinical rotations. Fine-tuning of the activity will be variable based on the facilitators' overall goals and the small groups' skills and interests.

While this project makes use of a variety of Google products, it could be accomplished with other electronic whiteboard programs or pen and paper. Web-based or collaboration tools embedded in virtual meeting platforms could be substituted for Jamboard. Each group could determine its steps and write them on large temporary adhesive posters to create a collaborative flowchart outlining the required logic of the clinical decision support.

This project could be adapted to different-sized groups, different styles of learning, and groups with varying backgrounds. The introduction activity can be performed individually or in groups of two to four around a shared screen. A group of seven students could individually work on each parameter to create a single Jamboard. A group of students could go through all the parameters together if desired. We tried this variation in the second year. Once the students have completed their first parameter and understand the process, they tend to work through the additional parameters more quickly.

While we sought the middle ground with regard to technical complexity, there are opportunities to tailor the third part of the activity with the Google Sheet based on the prior experience of the learners and the end goal. At one extreme, students could skip the pseudocoding portion if the instructors wished to preselect the correct settings and have the students see the results on the dashboard. Alternatively, the instructors could expect the students to correctly identify the specific codes that would be found in an electronic health record for each parameter. Groups seeking a more detailed clinical informatics experience could explore the Google Sheet coding and get into specifics of the ICD, CPT, and HCPCS codes. They could brainstorm the additional next steps for this process such as automating messages to flagged patients and sending orders for tests to the physician to be reviewed and signed. Alternatively, groups could gain a brief introduction to informatics but choose to focus more on the clinical details of CRC screening and specifics of the tests. Finally, groups interested in public health and prevention could

spend time talking more about USPSTF, the qualities of a good screening test, and so on.

It is also possible to modify this activity to cover a different clinical topic. Few screening topics provide as many options as CRC screening, but USPSTF recommendations and other preventive services are applicable across organ systems and clinical specialties.

We sought the middle ground between self-directed and fully facilitated activities. Some of our learners found this confusing, so we may produce both a fully self-directed activity and a fully facilitator-guided version to allow flexibility in future implementations. This would involve more detailed student instructions for the former and more hands-on facilitator training for the latter.

The data quality activity performed during the initial didactic session has potential to be more robust with a greater degree of feedback to the group about how its members performed. This could provide a stronger lesson about the importance of accurate data entry, strategies to deal with incomplete or unstructured data, and technology practices that enhance quality data entry.

Some students with more or less computer programming/informatics experience found the activity too easy or too hard. We are considering self-selection of groups based on students' prior experience to form less variation within a single group, allowing a facilitator to tailor the experience to the needs of their small group. More advanced groups could skip or quickly work through early portions and spend more time in the details of clinical decision support and clinical care.

Appendices

A. Brief Introduction to Medical Coding.docx

B. USPSTF CRC Screening Summary.pdf

C. Clinical Informatics and Cancer Screening Introduction.pptx

D. Warm-Up Exercise Food Crate Cards.pptx

E. Warm-Up Exercise Jamboard.pdf

F. Clinical Decision Support Coding Jamboard.pdf

G. Colorectal Cancer Screening CDS Activity.xlsx

H. Faculty Orientation - Clinical Informatics Session.pptm

All appendices are peer reviewed as integral parts of the Original Publication.

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