# Clinical Decision Support at the Point-of-Order Entry: An Education Simulation Pilot with Medical Students

Marc H. Willis, DO, L. Alexandre Frigini, MD, Jay Lin, MD, David M. Wynne, MD, Karla A. Sepulveda, MD

**Rationale and Objectives:** We have been called to reform radiology undergraduate medical education (UME) curricula. Clinically available clinical decision support provides an opportunity to improve education regarding appropriate imaging utilization, patient safety, and cost-effective care.

**Material and Methods:** We created an education simulation portal utilizing integrated clinical decision support. The portal was then piloted with 34 volunteer medical students at our institution in a blended learning environment. A program assessment was performed utilizing the results from a qualitative survey, pre-test, and post-test.

**Results:** The large majority of medical students felt this supplemental education resource should be included in our UME curriculum (85.29%). All students perceived value in the education simulation portal. The students performed significantly better on the post-test in multiple categories (overall $P < .0001$), including Choosing Wisely topics ($P = .0207$).

**Conclusions:** Based on our program assessment from this pilot program, we believe this innovative educational resource has significant potential to fill curricular gaps in radiology UME curricula. This platform is scalable and can be further customized to fill needs across the continuum of medical education.

**Key Words:** Simulation education; clinical decision support; appropriateness; utilization; medical imaging.

## INTRODUCTION

Medical imaging is an integral component of medicine, spanning the continuum of care. The invention of imaging modalities such as computed tomography, magnetic resonance imaging, and molecular imaging has significantly increased the reliance on medical imaging in clinical practice during recent decades (1). Contemporaneously, complimentary advances in information technology, informatics, and analytics are evolving at a staggering rate. These changes are superimposed upon a backdrop of healthcare reform. Undergraduate medical education (UME) curricula typically are not reflective of the omnipresence of imaging in the modern clinical practice; traditional curricula have not kept pace with these rapid advancements in technology and do not fulfill the evolving educational needs of medical students.

A call to reform radiology UME curricula has been made by medical school and radiology leadership. The large majority of medical students (95%) will pursue specialties other than radiology; therefore, evidence-based imaging utilization, cost-effective care, appropriate use of intravenous contrast, and judicious exposure of patients to medical radiation are essential elements to include in UME curricula (2,3). Although the American College of Radiology Appropriateness Criteria (ACR-AC) is a long-standing resource designed and available to facilitate appropriate imaging utilization, utilization has been low among medical students. The lack of an easy-to-use electronic format has been likely a barrier to medical student usage of the ACR-AC (4).

We have not adequately prepared our future physicians to follow the mantra of ordering the "right test at the right time," which is of utmost importance during an era aimed at continuous quality improvement, bending the curve of rising healthcare cost, fostering a culture of safety and evidence-based medicine supplemented by resources such as clinical decision support (CDS). Simply stated, our profession has failed to provide radiology curricula and learning resources that will prepare our future physicians to succeed in our rapidly evolving healthcare system.

Education reform calls also include a national standardized radiology UME curriculum, readily available digital interactive education resources, and standardized assessment tools to

**Acad Radiol 2016;** 23:1309–1318

From the Baylor College of Medicine, 1 Baylor Plaza, MS: BCM 360, Houston, TX 77030. Received August 5, 2015; revised January 13, 2016; accepted January 19, 2016. **Address correspondence to:** M.H.W. e-mail: mwillis@bcm.edu

http://dx.doi.org/10.1016/j.acra.2016.01.020

motivate mastery of curriculum content and validate the importance of radiology education (2). General trends in medical student education include optimization of adult learning principles, quality improvement and patient safety (5), utilization of virtual patients (6), simulation (7), e-learning (8), and mobile health technologies (9). Technology is ubiquitous in the life of the current generation of technically savvy medical students making e-learning an effective option for medical student education. When integrated into a blended-learning strategy, e-learning allows educators to focus on facilitating learning and assessing competency, moving away from the traditional instructor-centered didactic distribution of content. The blended-learning approach is well aligned with a learner-centered approach to education. E-learning offers the additional benefits of standardized course content, decreasing the burden on educators in an era of increasing clinical demands, an opportunity for standardized assessment and cost-savings, which predominantly are realized by more efficient use of educators' time and decreased redundancy of education resources (8).

Our vision is to address national radiology curricular gaps and improve alignment with overall trends in medical education. We developed a supplemental education simulation portal with an aim to facilitate a blended learning environment that allows learners to hone their ability to appropriately select imaging studies, encourages a culture of safety, and provides important information regarding the cost of health care. This environment facilitates learning without compromising patient safety or unnecessary waste of medical resources at affiliated hospitals. We piloted the education simulation portal as a supplement to our UME radiology curriculum. At our institution, medical students do not have a required radiology rotation; therefore, our goal was to introduce our medical students to the ACR-AC and CDS at the beginning of their clinical rotations to improve awareness, facilitate learning beyond our traditional UME curriculum, and assess the students' perceived value of this education simulation portal. We are sharing our program assessment and experience implementing this novel educational approach at our institution. This platform is scalable and provides an opportunity for standardized education and competency-based assessment.

## MATERIALS AND METHODS

### Pilot Project

A pilot program was implemented for 34 volunteer second-year medical students (MS2) transitioning from their preclinical classes to clinical rotations. The pilot was offered at this point in their curriculum because all students had a relatively homogeneous educational experience thus far, and they had limited exposure to ingrained ordering patterns at our affiliated clinical institutions. Institutional review board approval was obtained for this project. The medical students participating in the pilot program were volunteers; this was not a required portion of their curriculum, and it did not affect their academic standing. Students were recruited by making two announcements prior to their regularly scheduled classes and a few emails, one sent on behalf of the investigators by an Associate Dean from our Office of Undergraduate Medical Education validating the project as a legitimate education opportunity. Participating students have been allowed to maintain access to the ACR Select CDS tool for their subsequent clinical rotations. The pilot program consisted of a hybrid classroom, blending a brief traditional classroom experience with a self-paced online learning module, summarized in Figure 1.

### ACR Select

Although the ACR-AC is an extensive reference for appropriate image ordering, the information was not previously available in a practical, easily consumable manner to facilitate use in the clinical setting. ACR Select is a web service provided by National Decision Support Company that integrates the ACR-AC in a user friendly, consumable format to provide evidence-based, clinical point-of-order decision support for referring medical providers in selecting the most appropriate imaging evaluation for patients. In addition to appropriateness rankings for utilization of modalities based on the queried clinical scenario, the feedback also includes the relative radiation level and offers a relative cost scale derived from the global Centers for Medicare and Medicaid Services' relative value unit per exam in the feedback panel. If the user would like more information on the queried subject, the panel also provides a link to the relevant online ACR-AC. ACR Select is a commercially available product that can be integrated into existing electronic health record platforms (10). To our knowledge, prior to this project, ACR Select has been used solely as a CDS tool and not as a standardized education tool or conduit for learner self-assessment.

### Education Portal

The education portal was utilized for the self-directed digital learning module. We built the module on the ACR's Radiology Curriculum Management System (RCMS) platform. Experts in various radiology subspecialties were recruited to author cases simulating common clinical scenarios from a primary care practice setting and representative of the available appropriateness categories within the ACR Select portal. Primary care was selected as the theme for the cases because at our institution the medical students have a longitudinal primary care clinical experience embedded in their traditional preclinical curriculum, thus ensuring the students had a clinical context and instructional scaffolding for the content of the pilot. Each case author was also asked to include question(s) regarding any Choosing Wisely topic that pertained to their section. Choosing Wisely is an initiative of the American Board of Internal Medicine to promote more effective use of healthcare resources. The cases were assigned a difficulty level (introductory, intermediate, and advanced) based on expected level of knowledge at the MS2 level and loaded into the RCMS. RCMS and ACR Select were integrated via

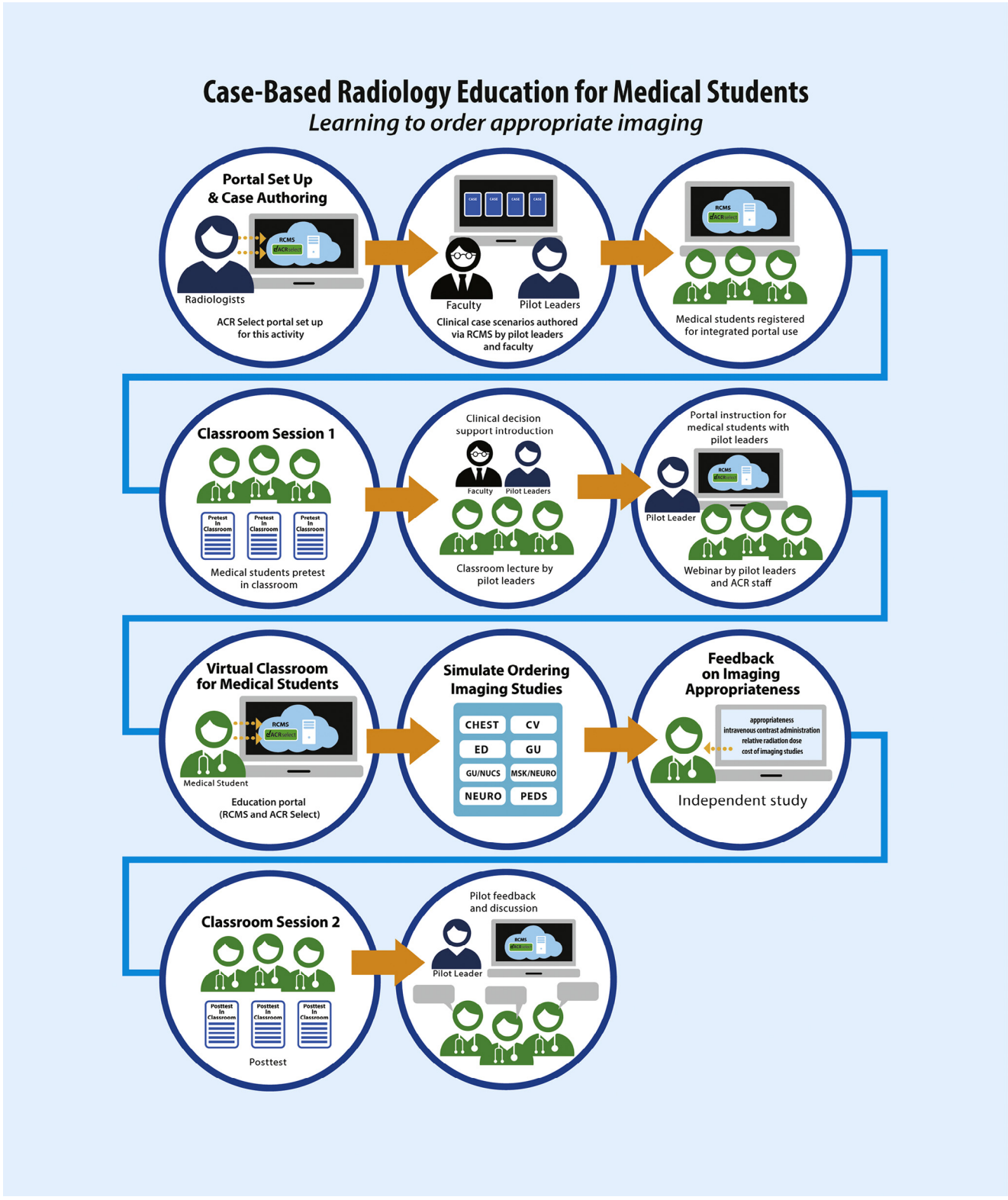


**Figure 1.** Pilot Project Steps.

application programming interface to provide learners with seamless connectivity between the cases in the RCMS education portal and CDS via the ACR Select online portal. Learners navigated through the ACR Select portal to receive CDS prior to selecting the appropriate imaging study for the cases in RCMS simulation environment. Learners received instant feedback regarding correct and incorrect answers and had immediate access to the relevant ACR Select CDS table. This feedback

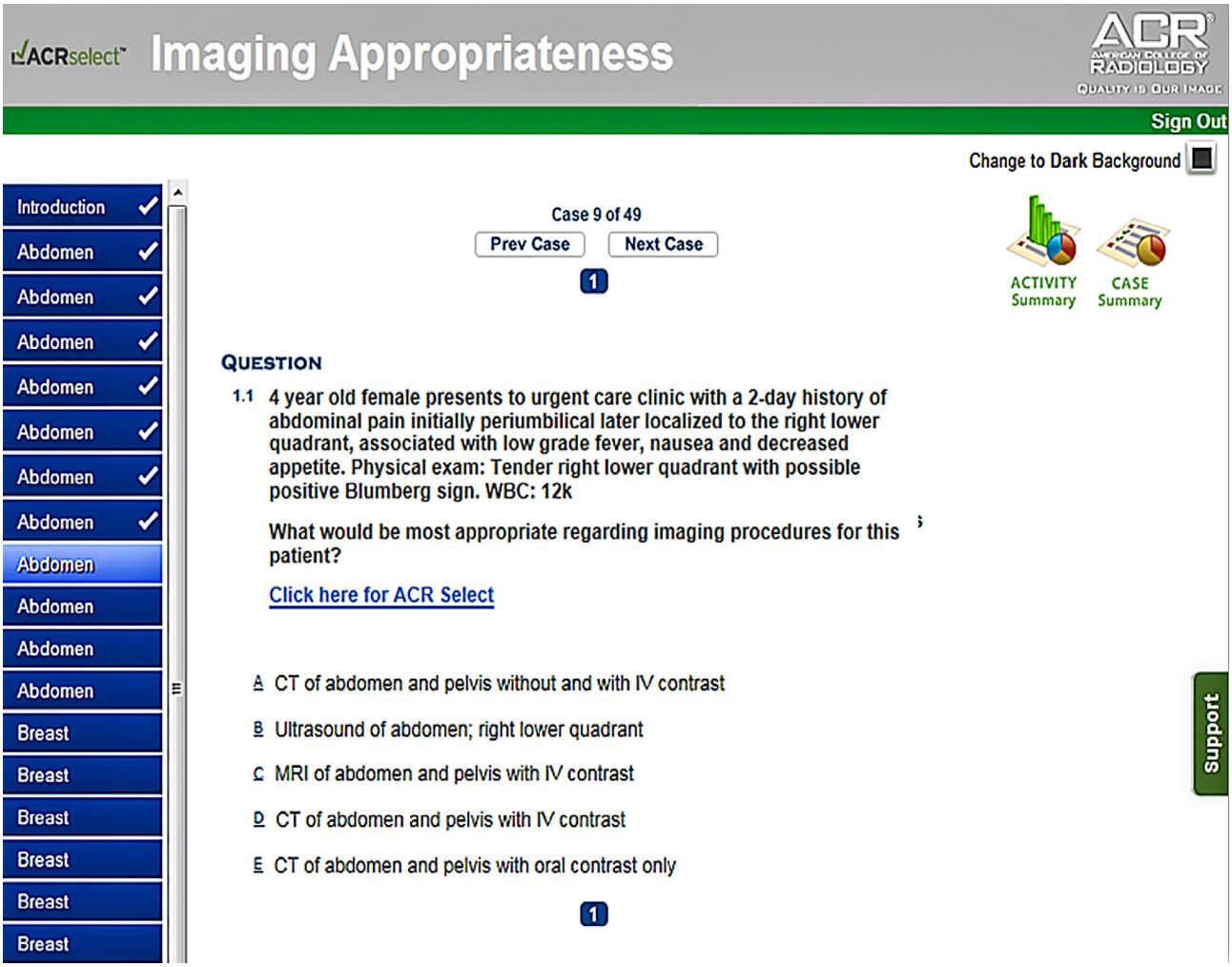


**Figure 2.** Simulation Portal: An example case.

is provided to reinforce knowledge and/or for learners to verify that they have correctly navigated through the ACR Select CDS portal. Figure 2 provides an example case from the education portal. Figure 3 demonstrates the integrated CDS.

### Pre-Test

The volunteer students met with facilitators from the author team in a classroom setting and took a pre-test administered through an institutional account with a commercially available web-based survey tool. The students did not have access to CDS for the pre-test. The pre-test consisted of 20 questions, 19 multiple-choice and one self-assessment question. The first 12 multiple-choice questions consisted of patient case scenarios, and the students were asked to select the most appropriate choice regarding imaging procedures for the simulated patient. The questions were reviewed by the medical students' course director for their primary care clerkships. The course director verified case difficulty levels based on the medical students' expected level of knowledge and amount of exposure to the clinical topics at the end of their preclinical curriculum. The director was requested to assign a level of "Introductory" if most medical students with their level of clinical experience should answer the question correctly, "Intermediate" if approximately 50% of medical students with their level of clinical experience should answer correctly, and "Advanced" if most medical students with their level of clinical experience would not be expected to answer correctly. The course director verified four questions at the introductory level, four questions at the intermediate level, and four questions at the advanced level. The topic for one introductory question, one intermediate question, and one advanced question specifically addressed content relating to the Choosing Wisely list for imaging appropriateness, which was developed in collaboration with the American College of Radiology (11). The three topics covered from the list were "Don't recommend follow-up imaging for clinically inconsequential adnexal cysts," "Avoid admission or preoperative chest X-rays for ambulatory patients with unremarkable history and physical exam," and "Don't do computed tomography (CT) for the evaluation of suspected appendicitis in children until after ultrasound has been considered as an option (12)."


**Figure 3.** Clinical Decision Support Portal Interface and Feedback Panel.

The next four questions were related to strengths and weakness of particular modalities and when they would be appropriate to utilize. The following two questions asked the learners to rank in order the appropriateness of five imaging choices for a patient scenario, including appropriate use of intravenous contrast. The last question was a self-assessment question regarding the learner's self-perceived preparation to appropriately select imaging studies for their patients utilizing a Likert scale with anchors ranging from "Totally unprepared" to "Totally prepared."

## INTRODUCTION TO THE PILOT PROJECT

After completing the pre-test, the students were given a 10-minute introduction to evidence-based medicine and CDS via a traditional lecture. Next, an ACR staff member oriented the medical students to the RCMS portal via a brief webinar utilizing a commercially available web-hosted service for online meetings. The students subsequently divided into small groups of six to eight students; each group was facilitated by a faculty member from the author team. The facilitators ensured that each learner could technically navigate through the integrated RCMS-ACR Select web-based learning environment prior to concluding the session to ensure student performance was not limited by technical challenges with the program. The learners were instructed that they would subsequently return for a follow-up traditional classroom experience to take a post-test, and at that time key members of the author team would again be available to answer questions and accept learner feedback.

### Simulation Education

During the following 2 weeks, the learners engaged in their simulation education experience with integrated CDS via the RCMS-ACR Select education portal. The portal consisted

of 48 cases, distributed evenly between musculoskeletal radiology, breast imaging, gastrointestinal imaging, thoracic and cardiac imaging, genitourinary imaging, neuroradiology, women's imaging, and vascular imaging. The learning module simulated ordering of imaging studies with the assistance of CDS at the time of order entry. The students received immediate feedback via the ACR Select CDS tables. Additional learner-directed education was available via links to the relevant ACR-AC online resource for each case.

### Post-Test

After 2 weeks, the learners returned to the traditional classroom setting and took a post-test. The post-test was administered in a manner similar to the pre-test; the students also did not have access to CDS during the post-test. The content of the first 20 questions were similar to the pre-test; each case was slightly modified by changing the demographics and/or the order of the answers without altering the clinical context of the case. This was done to prevent the possibility that learners might recognize or recall questions from the pre-test. Nine additional survey questions were included at the end of the post-test, including topics such as hours spent in the virtual classroom, approach to completing the virtual classroom assignment, utilization of the CDS during the virtual classroom, value of CDS for learning, and opinion about including CDS in the medical school curriculum. Additional open-ended questions were included at the end to assess motivation and encourage feedback for portal improvements and general comments.

### Wrap-Up

The pilot project concluded with a 30-minute "open mic" session allowing medical students to provide verbal feedback regarding their experience, recommendations for improvements to the education tools, and insight into their vision of how this pilot could be best integrated into medical student education.

### Program Evaluation

At the end of the pre-test and post-test, the learners were asked to self-assess their level of preparation to appropriately order imaging studies for their patients. At the end of the post-test, learners were asked a series of survey questions, including how valuable they found the education simulation with integrated CDS experience in learning about appropriate imaging utilization, if the education portal should be included in the medical school curriculum, and time spent in the portal. We also asked the learners open-ended survey questions: "What motivated you to participate in this voluntary pilot project?", "How could the education portal (virtual classroom) be improved?", and "How could the clinical decision support tool (ACR Select) be improved?" We identified the most common answer themes from the responses and calculated the number of occurrences of each. A statement could count as more than one category if the statement covered more than one of the themes.

The pre-test and post-test answers from the 34 learners completing the pilot project were matched by anonymized identification numbers. Correct answers pre-test versus post-test were compared via the Wilcoxon signed-rank test. The Wilcoxon signed-rank test is the nonparametric version of the paired *t* test. All questions were analyzed in aggregate as one group, "Overall Performance." The case scenario questions were separately analyzed by the difficulty level, "Introductory Cases," "Intermediate Cases," and "Advanced Cases." The modality specific questions ("Modality Questions") and appropriate order sequence questions were each analyzed separately. The case-scenario questions which pertained to Choosing Wisely topics were additionally analyzed as a separate group ("Choosing Wisely Topics"). Sequencing questions asked the learners to rank the imaging studies in order based on appropriateness for a given case scenario. Additional analysis of the sequencing questions was performed by ranking each answer from best answer to least correct answer. The best answer was given a score of 5; the second best answer a score of 4, and so on through the least appropriate answer given a score of 1.

## RESULTS

For the self-assessment of preparation to appropriately order imaging studies, on the pre-test survey, the responses ranged from "Totally Unprepared" (13.16%) to "Slightly Prepared" (13.16%), with the majority of the learners saying they were "Unprepared" (57.89%). On the post-test survey, students' perceived increased preparedness to order imaging appropriately. The responses ranged from "Unprepared" (11.76%) to "Slightly Prepared" (58.82%), which was the majority of the learners (Figs 4 and 5). Of note, no students answered "Totally Unprepared" on the post-test. When students were asked about their perceived value of the pilot on the post-test, the answers

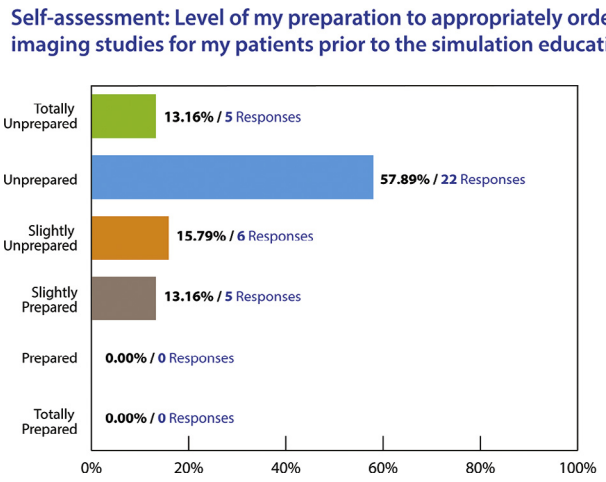


**Figure 4.** Survey Results: Prior to Simulation Education.

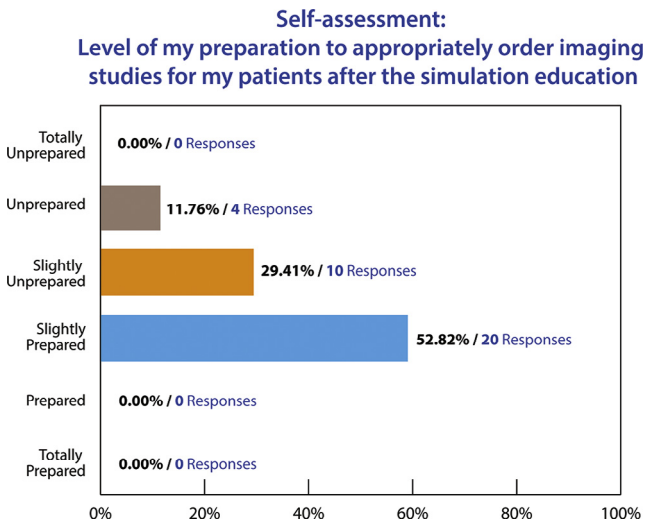


**Figure 5.** Survey Results: After Simulation Education.

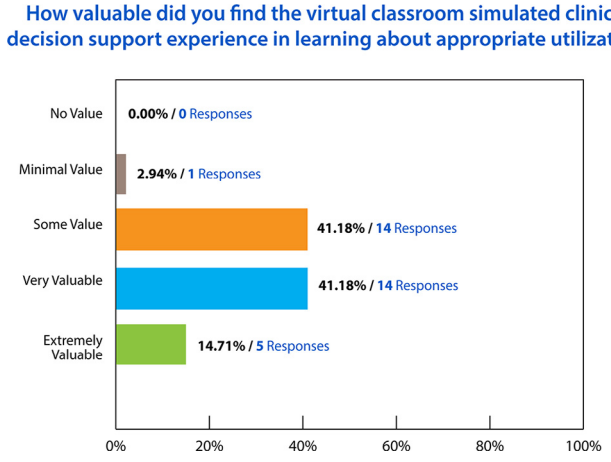


**Figure 6.** Survey Results: After Simulation Education.

ranged from the following: "Minimal Value" (2.94%), "Some Value" (41.18%), "Very Valuable" (41.18%), and "Extremely Valuable" (14.71%) (Fig 6). When asked if the education portal with simulated CDS should be included in the medical school curriculum, 85.29% of the learners responded "Yes" (Fig 7).

The majority of learners (73.53%) spent 1-3 hours in the education portal. There was no statistically significant difference in the learners' performance based on their speed of moving through the cases.

In the open-ended survey questions, three most frequent answer themes were identified for what motivated student participation: learn more about ordering studies appropriately, learn more about radiology, and access to the CDS tool (ACR Select) for clinical rotations. A summary of the responses can be seen in Table 1. The three most common themes for recommendations for improvement to the portal were technical improvements (less clicks being the most common), more learning pearls provided with the answers, and no improvement recommended. The responses are summarized in Table 2. The most common responses for improvement to ACR Select were optimize organization of the lists or columns within the portal, more readily accessible supplemental information and explanations with the CDS feedback, improved search tool function, and less scrolling within the interface. The responses are summarized in Table 3.

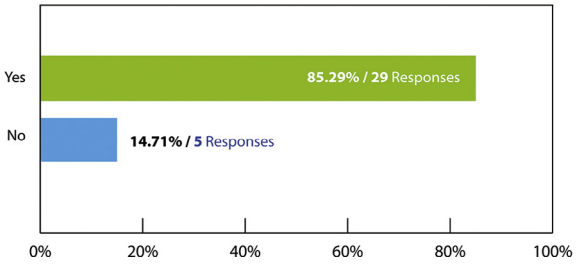


**Figure 7.** Survey Results: After Simulation Education.

Analysis of the data demonstrated a statistically significant improvement in the number of correct answers from the pre-test to the post-test in four categories: Intermediate Cases ($P < .0001$), Advanced Cases ($P = .0013$), Choosing Wisely Topics ($P = .0207$) and the Overall Performance ($P < .0001$). These results are summarized in Table 4. The sequencing questions asked the learners to rank the imaging studies in order based on appropriateness for a given case scenario (pre-test $0.47 \pm 0.56$ out of 2 and post-test $0.56 \pm 0.66$ out of 2). Additional analysis of the sequencing questions was performed by ranking each answer from best answer to least correct answer. The best answer was given a score of 5; the second best answer a score of 4, and so on through the least appropriate answer given a score of 1. The pre- and post-test scores were also compared via Wilcoxon signed-ranked test. The analysis showed a slight improvement of the scores from the pre-test (8.45 +/- 2.38) to the post-test (8.94 +/- 2.36), but this was not statistically significant ($p$-value 0.4625).

## DISCUSSION

We successfully piloted an education simulation portal as a supplemental resource to introduce our medical students to the ACR-AC and CDS early in their clinical rotations. The large majority of our students perceived value in this simulation exercise, desire for its inclusion in our curriculum, and improved in their ability to successfully select the most appropriate imaging in multiple categories including Choosing Wisely. We wanted to expose our students to these topics early in their transition from the classroom to their clinical rotations. It is our hope that by improving their awareness early in their clinical education, they will have ample time and opportunities to further build upon this knowledge throughout their clinical rotations. We ensured our participating students that they will have continued access to the ACR Select portal

**TABLE 1. What Motivated You**

| Post-test Survey Question and Comments | |
|---|---|
| What motivated you to participate in this voluntary pilot project? | |
| Survey of the 38 learners completing the pilot | Responses |
| Learn more about ordering studies appropriately | 11 |
| Learn more about radiology | 10 |
| To have access to the clinical decision support tool (ACR Select) | 6 |
| To be helpful (medicine in general, my school) | 4 |
| Intrigued by the novel approach to learning | 4 |
| Become a better doctor | 2 |
| **Specific Comments** | |
| "I really think there is an excess of ordering radiology tests in patients and I want to be a doctor who does what is needed and evidence proven, not someone who orders everything just to cover all the bases." | |
| "I think that imaging is a huge part of the diagnostic process of medicine. There are so many different options that many clinicians and students do not fully understand so less appropriate tests of unnecessary tests are ordered that increase cost and increase discomfort and/or radiation exposure to the patient. This program could really help in preventing this and better guiding imaging decisions." | |
| "I do not feel prepared to order correct imaging based on what I have learned in medical school so far. There is definitely a need for this in the curriculum." | |
| "I felt highly unprepared when it comes to imaging modalities and ordering the appropriate tests, and felt overwhelmed by the radiology course in the pre-clinical curriculum. I thought this pilot program was a unique and interesting way to get more experience." | |
| "Opportunity to participate with cutting edge clinical decision support software, which I feel is the future of medicine. I would also like to continue to use the program after the study." | |

ACR, American College of Radiology.

**TABLE 2. Education Portal**

| Post-test Survey Question and Comments | |
|---|---|
| How could the education portal be improved? | |
| Survey of the 38 learners completing the pilot | Responses |
| Recommended technical improvements:<br>• Less clicks (6)<br>• Increased interface speed (3)<br>• Log-in (3)<br>• General (2) | 13 |
| More learning pearls provided with the answers | 12 |
| No recommendations and/or positive comment | 7 |
| Better matching of question stem with ACR Select information | 3 |
| **Specific comments** | |
| "The cases were great overall. More explanation about the correct answer would be helpful in terms of learning. For instance, I'm still very confused about when to use contrast." | |
| "I think that it has a lot of potential. Something that I would have found immensely useful would have been a short summary stating why the appropriate test was chosen (thought process, etc.)." | |

ACR, American College of Radiology.

throughout their rotations to facilitate additional self-directed, evidence-based learning. In this article, we are sharing this initial program assessment and our experience piloting this supplemental educational resource.

Learner feedback regarding this project was extremely positive; the overwhelming majority of learners believe this simulation should be included in their medical school curriculum which is a testament to the perceived value by the learners. Although not the primary goal of this pilot, the learners showed statistically significant improvement in the majority of the categories from the pre-test to the post-test in this simulated environment. Perhaps most encouraging was their statistically significant improvement in "Choosing Wisely Topics"; improvement in this category highlights the potential of this education portal to address a critical need in healthcare education with an aim of reducing waste in medicine.

**TABLE 3. Support Tool**

How could the clinical decision support tool (ACR Select) be improved?

| Survey of the 38 learners completing the pilot | Responses |
|---|---|
| Improved organization of the lists and columns within the interface | 12 |
| More information ("learning pearls") in the decision support table | 9 |
| Improved function of the search tool | 7 |
| Less scrolling within the interface | 6 |

ACR, American College of Radiology.

Limitations of this pilot project include the relatively small sample size and single institution involved. The short duration of this pilot limited our ability to assess for an enduring impact in areas such as retention of knowledge or continued use of decision support as the students progressed through their clinical rotations; these areas should be further evaluated in future research. We are not advocating this approach as a "one-size-fits-all" approach to medical student education. This resource should be investigated at multiple institutions, in multiple situations, and on a larger scale. We also are not advocating that our pilot program be a stand-alone substitute for a robust radiology curriculum. The flexibility of the platform allows for each institution to implement within their curriculum in a way that makes sense for their curriculum. This tool could be implemented in a longitudinal fashion to further supplement and reinforce what students learn as they progress through their clinical rotations. We believe that the ACR-AC and CDS should be further integrated into the UME curriculum during medical students' clinical rotations to provide "just-in-time" education regarding these topics. When planning this activity, we believe it is important to consider the contemporaneous curricular demands on learners.

This education portal has potential to fulfill education gaps in UME and beyond. The Institute of Medicine recently released their third report *Improving Diagnosis in Health Care* (13), the follow-up to *To Err is Human: Building A Safer Health System* (2000) and *Crossing the Quality Chasm: A New Health System for the 21st Century* (2001). Stated goals for improvement in this report include "Enhance health care professional education and training in the diagnostic process" and "Ensure that health information technologies (IT) support patients and health care professionals in the diagnostic process" (13). Physicians have been called to embrace decision support (14), and the Protecting Access to Medicare Act of 2014 (H.R. 4302) legislation will eventually require referring providers to consult physician-developed appropriateness criteria when requesting advanced imaging procedures for patients covered by Medicare (15,16). Thus, there is potential for a much broader application of this education resource.

## CONCLUSION

Our profession has been called to transform UME radiology education. A representative approach to UME requires a robust radiology curriculum vertically and horizontally integrated throughout a curriculum. Radiologists must embrace this challenge and develop innovative ways to address these curricular gaps. Aligned with these efforts for improvement, we designed and implemented this supplemental educational resource to aide in the education of our students in the diagnostic process. We believe our novel approach is a move in the right direction for medical student education. It delivers value, lowers the barrier to appropriate imaging utilization education, and makes a meaningful and demonstrable contribution to medical education. Using readily available CDS software, our profession has an opportunity to champion improved education in the areas of appropriate imaging utilization, patient safety, and the cost of health care. We believe this platform can be a foundation for development of a nationally recognized radiology UME curriculum and provide a standardized competency-based assessment tool. This web-based product is scalable and can be customized to serve as an education resource for graduate medical education, allied health education, Performance Quality Improvement projects, continuing medical education for practicing medical providers, and interprofessional education. In an era of evidence-based medicine, continuous quality improvement, and patient safety, combining simulation training at the point-of-order with integrated CDS into medical student education provides an effective way to engage our future physicians before they establish their

**TABLE 4. Pre-test and Post-test**

Results: Pre-test and Post-test

| | Pre-test | | | Post-test | | | |
|---|---|---|---|---|---|---|---|
| Variable | *N* | Mean ± SD | 15/50/85 Percentile | *N* | Mean ± SD | 15/50/85 Percentile | *P*-Value |
| Introductory cases | 38 | 3 ± 0.77 | 2/3/4 | 34 | 3.03 ± 0.63 | 2/3/4 | .7501 |
| Intermediate cases | 38 | 1.74 ± 0.95 | 1/2/3 | 34 | 3 ± 0.85 | 2/3/4 | <.0001 |
| Advanced cases | 38 | 1.66 ± 0.97 | 1/2/2.15 | 34 | 2.26 ± 0.86 | 1.25/2/3 | .0013 |
| Modality questions | 38 | 1.95 ± 1.11 | 1/2/3 | 34 | 2.24 ± 1.05 | 1/2/3 | .0731 |
| Choose Wisely topics | 38 | 1.5 ± 0.92 | 0.85/1/3 | 34 | 1.85 ± 0.74 | 1/2/3 | .0207 |
| Overall performance | 38 | 8.82 ± 2.06 | 6/9/11 | 34 | 11.1 ± 1.9 | 9/11/13 | <.0001 |

practice habits. Expanding these efforts across the continuum of medical education is a logical next step to broaden the enduring impact, change behaviors, and more rapidly improve patient outcomes.

## ACKNOWLEDGMENTS

We gratefully acknowledge the contribution of our team. Education Portal:

Marc H. Willis, DO—Project Sponsor, Chief Editor and Musculoskeletal Imaging Author
Karla A. Sepulveda, MD—Co-Editor and Breast Imaging Author
L. Alexandre Frigini, MD—Gastrointestinal Imaging Author
Veronica V. Lenge De Rosen, MD—Thoracic and Cardiac Imaging Author
Jay Lin, MD—Genitourinary Imaging Author
Pedro J. Diaz-Marchan, MD—Neuroradiology Imaging Author
Erik V. Soloff, MD—Women's Imaging Author
David M. Wynne, MD—Vascular Imaging Author

We sincerely thank Wei Zhang, Ph.D. for her statistical analysis.

We additionally appreciate the collaboration of the American College of Radiology and National Decision Support Company in construction of the education portal. Specifically, the invaluable assistance of staff members Becky Haines, Senior Director, ACR Press/Imaging 3.0, and Michele Huneke, System Analyst, Product Development.

Marc H. Willis, DO, was the 2015 recipient of the American Roentgen Ray Society's Leonard Berlin Scholarship in Medical Professionalism.

## REFERENCES

1. Health Affairs Website. Physicians' views of the relative importance of thirty medical innovations. Available at: http://content.healthaffairs.org/content/20/5/30/T3.expansion.html. Accessed May 13, 2015.
2. Straus C, Webb E, Kondo K, et al. Medical student radiology education: summary and recommendations from a national survey of medical school and radiology department leadership. J Am Coll Radiol 2014; 11:606–610.
3. National Resident Matching Program. Results and data: 2015 main residency match. Available at: http://www.nrmp.org/wp-content/uploads/2015/05/Main-Match-Results-and-Data-2015_final.pdf. Accessed June 6, 2015.
4. Kozak B, Webb EM, Khan BK, et al. Medical student usage of the American College of Radiology Appropriateness Criteria. Acad Radiol 2015; 22:1606–1611.
5. Wong B, Etchells E, Kuper A, et al. Teaching quality improvement and patient safety to trainees: a systematic review. Acad Med 2010; 85:1425–1439.
6. Cook D, Erwin P, Triola M. Computerized virtual patients in health professions education: a systematic review and meta-analysis. Acad Med 2010; 85:1589–1602.
7. Ziv A, Wolpe P, Small S, et al. Simulation-based medical education: an ethical imperative. Acad Med 2003; 78:783–788.
8. Ruiz J, Mintzer M, Leipzig R. The impact of e-learning in medical education. Acad Med 2006; 81:207–212.
9. Gaglani S, Topol E. iMedEd: the role of mobile health technologies in medical education. Acad Med 2014; 89:1207–1209.
10. ACR Select. National Decision Support Company Website. Available at: http://www.acrselect.org/index.html. Accessed May 14, 2015.
11. ACR Website. The Choosing Wisely Imaging Exam Topics. http://www.acr.org/Advocacy/Economics-Health-Policy/Imaging-3/PQI-Initiative/Choosing-Wisely-Topics. Accessed November 17, 2015.
12. Choosing Wisely Website. Five things physicians and patients should question. http://www.choosingwisely.org/wp_content/uploads/2013/01/5things_12_factsheet_Amer_Coll_Radiology.pdf. Accessed May 14, 2015. 2012.
13. Institute of Medicine. Improving diagnosis in health care. http://iom.nationalacademies.org/Reports/2015/Improving-Diagnosis-in-Healthcare.aspx. Accessed October 23, 2015.
14. ACR Website. Radiologists and clinical decision support. http://www.acr.org/Advocacy/Economics-Health-Policy/Imaging-3/Presentations/Radiologists-and-Clinical-Decision-Support. Accessed May 14, 2015.
15. ACR Website. Landmark medical imaging provisions in SGR "patch" to help usher in new era of evidence-based medicine. http://www.acr.org/About-Us/Media-Center/Press-Releases/2014-Press-Releases/20140331Landmark-Medical-Imaging-Provisions-in-SGR-Patch. Accessed May 14, 2015, 2014.
16. Congress Website. H/R/4302-Protecting access to Medicare Act of 2014. https://www.congress.gov/bill/113th-congress/house-bill/4302. Accessed May 14, 2015. 2014.