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Knowledge Translation and Barriers to Imaging Optimization in the Emergency Department: A Research Agenda

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Abstract

Researchers have attempted to optimize imaging utilization by describing which clinical variables are more predictive of acute disease and, conversely, what combination of variables can obviate the need for imaging. These results are then used to develop evidence-based clinical pathways, clinical decision instruments, and clinical practice guidelines. Despite the validation of these results in subsequent studies, with some demonstrating improved outcomes, their actual use is often limited. This article outlines a research agenda to promote the dissemination and implementation (also known as knowledge translation) of evidence-based interventions for emergency department (ED) imaging, i.e., clinical pathways, clinical decision instruments, and clinical practice guidelines. We convened a multidisciplinary group of stakeholders and held online and telephone discussions over a 6-month period culminating in an in-person meeting at the 2015 *Academic Emergency Medicine* consensus conference. We identified the following four overarching research questions: 1) what determinants (barriers and facilitators) influence emergency physicians' use of evidence-based interventions when ordering imaging in the ED; 2) what implementation strategies at the institutional level can improve the use of evidence-based interventions for ED imaging; 3) what interventions at the health care policy level can facilitate the adoption of evidence-based interventions for ED imaging; and 4) how can health information technology, including electronic health records, clinical decision support, and health information exchanges, be used to increase awareness, use, and adherence to evidence-based interventions for ED imaging? Advancing research that addresses these questions will provide valuable information as to how we can use evidence-based interventions to optimize imaging utilization and ultimately improve patient care.

There are currently numerous evidence-based interventions focused on improving resource utilization for emergency department (ED) diagnostic imaging, including clinical practice guidelines, clinical decision instruments, and clinical pathways.^{1–12} Designed by researchers, professional societies, and individual institutions across the international emergency medicine (EM) community, their purpose is to assist clinicians with decision-making in specific clinical situations (e.g., mild head injury) to safely reduce ED imaging while identifying clinically important disease. Multiple clinical decision instruments have been shown to have high sensitivity and sufficient specificity to safely decrease imaging rates without compromising patient outcomes.^{1,5,6,13,14} Various evidence-based clinical practice guidelines have also been developed to aid ED clinicians in certain diagnostic situations (e.g., syncope, seizure, acute headache) to improve resource utilization with regards to ED imaging.^{10–12}

Recently, the American College of Emergency Physicians released 10 recommendations as part of the “Choosing Wisely” campaign, five of which pertain to unnecessary imaging.¹⁵ If properly implemented and used, these evidence-based interventions have the potential

to optimize imaging utilization resulting in lower costs, decreased radiation exposure, enhanced ED throughput, and improved patient care. Yet, this guidance is not commonly used in actual ED clinical practice.¹⁶ A recent national survey on diagnostic imaging revealed that the vast majority of emergency physicians (EPs) believe that roughly one in five imaging studies ordered in the ED are medically unnecessary.¹⁷ Fear of missing a diagnosis and medicolegal concerns were most often cited as contributing factors to obtaining imaging, while shared decision-making and tort reform were cited as potential solutions.^{17,18} The objective of this article is to provide a consensus-driven summary, including a literature review and research agenda, regarding dissemination and implementation of evidence-based interventions to optimize imaging in the ED. Although optimal imaging rates may be characterized differently by various stakeholders (patients, EPs, consultant physicians, administrators, or payers), for the purpose of this article, we define it as the rates of use of imaging that maximize the benefit/harm ratio for patients while reducing waste.

METHODS

This article is a product of a 6-month process consisting of a substantial review of the literature, monthly hour-long group conference calls, and an in-person planning meeting, ultimately culminating in the *Academic Emergency Medicine* consensus conference in San Diego in May 2015. Our group, consisting of a multidisciplinary team of EPs, emergency radiologists, and psychologists with expertise in decision science, was tasked with creating a research agenda to guide future efforts focusing on the dissemination and implementation, also known as knowledge translation,¹⁹ of evidence-based interventions for diagnostic imaging in the ED. Through an iterative process, a list of four overarching research questions was compiled and developed in parallel by four subgroups. These questions address dissemination and implementation from four different and partially overlapping perspectives: the physician, the institution, health care policy, and health information technology. Although important, we did not specifically discuss dissemination and implementation from the perspective of patients or private payers, because these stakeholders generally have an indirect effect on the uptake of evidence-based interventions for ED imaging. The initial draft of the article was discussed and then revised during and after the consensus conference itself.

Research Question 1: What are the determinants (facilitators and barriers) of EPs' use of evidence-based interventions when deciding to order diagnostic imaging?

Identifying and addressing the gaps between evidence-based practice and actual clinical care is the goal of dissemination and implementation science, also known as knowledge translation.¹⁹ One critical, early dissemination and implementation step is identifying the determinants (barriers and facilitators) of evidence use in relevant clinical situations.

There are multiple conceptual models/frameworks that have been developed to assess the barriers and facilitators to evidence uptake and use by physicians.^{16,20,21} These conceptual frameworks can help researchers standardize the terminology, study design, and analytic techniques used in this domain of implementation science. It is not the objective of this

article to compare and discuss all of these frameworks, but rather to mention some of those most widely accepted and used to study barriers and facilitators to ED-based interventions.

The Clinical Practice Guidelines Framework for Improvement is one highly regarded means to evaluate barriers to evidence-based guidance uptake in health care.¹⁶ It consists of seven distinct domains across three themes: knowledge, attitudes, and behavior. The domains include: 1) awareness of guidelines, 2) familiarity with the guideline, 3) agreement with the recommendations, 4) self-efficacy (perception that one can carry out the recommendations), 5) outcome expectancy (perception that following the guideline will lead to improved outcomes), 6) inertia of previous practice, and 7) external barriers. Although this framework could be used to guide studies to evaluate the determinants of evidence-based guidance use in the ED for diagnostic imaging, we were unable to identify research that has done so.

Some studies looking at the use of prediction rules or guidelines for ED imaging have used the Theoretical Domains Framework (TDF).^{22,23} The TDF integrates constructs from 33 behavior change theories and consolidates them in a more accessible arrangement of 12 theoretical domains.²³ The 12 domains are 1) knowledge; 2) skills; 3) social/professional role and identity; 4) beliefs about capabilities; 5) beliefs about consequences; 6) motivation and goals; 7) memory, attention, and decision processes; 8) environmental context and resources; 9) social influences; 10) emotion regulation; 11) behavioral regulation; and 12) nature of the behavior.²⁰ Curran et al.²³ assessed whether the TDF could be used to retrospectively identify the determinants of use of the Canadian Computed Tomography (CT) Head Rule after an implementation trial. The TDF was also used to analyze factors thought to influence the use of clinical practice guidelines and clinical decision instruments for the management of mild traumatic brain injury in Australian EDs. The authors concluded that these determinants ranged across a variety of theoretical domains, which could serve as targets for future interventions.²² Further studies, using existing conceptual frameworks, are needed to explore which factors influence the use of evidence-based interventions for ED diagnostic imaging in general, as well as in specific clinical scenarios where well-validated and accepted clinical decision instruments exist, e.g., the Canadian CT Head Rule for adult blunt head trauma² and the PECARN criteria for pediatric blunt head trauma.⁶

To better understand the determinants of evidence use in the ED, qualitative designs, such as focus groups and stakeholder interviews, are often required both at the intervention planning phase and postimplementation phase. Unfortunately, these studies are infrequently completed.^{19,24} Future qualitative research must study ED providers as well as patients and administrators (who influence decision-making). Other potential research to understand determinants to use or lack of use of evidence-based interventions includes ethno-graphic studies (e.g., workflow analyses) of ED clinicians making imaging decisions in real time and surveys of ED clinicians (and patients) to understand regional and national perspectives. Studies employing the Delphi method using key EM opinion leaders could also provide valuable data in this area. Since each ED possesses unique organizational, professional, individual, and cultural characteristics, the identification of specific barriers and facilitators may be most useful to inform the implementation of a particular intervention in a given ED. Finally, meta-analyses of studies evaluating determinants of knowledge use, accounting

for heterogeneity across studies, could also be helpful. Collectively, this research agenda should help delineate and describe the barriers and facilitators of emergency clinicians' use of evidence-based interventions for diagnostic imaging.

To better understand evidence-based intervention use among EPs, the group recommended the following specific determinants be investigated.

1. To what extent do the following potential barriers affect evidence-based intervention use for ED imaging?
 - Lack of knowledge or awareness of the evidence-based intervention
 - Lack of belief in effectiveness of the evidence-based intervention
 - Disruption to clinical workflow or time expectations
 - Expectations of patients, admitting or consulting physicians, or administrators
 - Fear of litigation
 - Fear of missing or delaying a diagnosis
 - Financial incentive to order imaging
2. To what extent do the following potential facilitators affect evidence-based intervention use for ED imaging?
 - Educational interventions including information sheets, physician-led presentations, or workshops
 - Financial incentives to safely reduce imaging or follow institutional guidelines
 - Audit and feedback of clinician ordering rates and evidence-based intervention use, and tying utilization rates to clinical outputs (e.g., diagnostic yield) or outcomes (e.g., diagnosis, readmission, mortality)
 - Mandatory clinical decision support system completion for image ordering

Research Question 2: What implementation strategies can improve the use of evidence-based interventions with regard to ED imaging?

Investigators in health care settings other than the ED have studied the effectiveness of multiple implementation strategies (e.g., guideline implementation to maximize hand washing and minimize intravenous line infections), with the interventions based on a variety of conceptual frameworks.^{25–27} Unfortunately, studies of clinical decision instruments aimed to optimize imaging in the ED have often lacked conceptual frameworks and consequently neglected to provide guidance for future implementation efforts.^{4,5} The Consolidated Framework for Implementation Research attempts to consolidate and unify key constructs across the numerous prior implementation frameworks and theories.²⁸ The Framework provides investigators a useful matrix of underlying constructs in the following five overarching domains that can be used to choose, develop, and report on

implementation strategies: 1) the characteristics of the intervention, 2) and 3) the context within which the intervention will be implemented (divided into “inner” [2] and “outer” [3] settings), 4) characteristics of individuals (e.g., ED providers), and 5) the process for rollout and evaluation of the intervention. The Consolidated Framework (and many individual frameworks) highlight the need to not only study the objective outcomes of implementation strategies (e.g., use of CT) but study and report on the contextual factors (e.g., practice setting, peer beliefs, patient needs, resources) that influence, for example, the fidelity of the behavior change, adaptability between sites, and sustainability of the intervention. Although evaluation frameworks exist to measure these factors, the majority of prior EM studies have not focused on them, which has hindered the ability to replicate dissemination and implementation studies in heterogeneous institutional contexts.

Investigators have a substantial number of implementation strategies among which to choose, many of which are relevant to influencing ED imaging use. Powell et al.²⁹ provided a useful compilation of discrete implementation strategies, categorized in the following six groups: 1) *planning strategies* that include needs assessments and stakeholder engagement; 2) *education strategies*, such as educational outreach, learning collaboratives, and mass media; 3) *financial strategies*, including incentives that motivate guideline adoption; 4) *restructuring strategies*, such as changing existing roles, services, and physical structure; 5) *quality management strategies*, such as development and use of decision support and data systems; and 6) *policy changes* (such as tort reform) and public campaigns. Relevant examples of implementation strategies within these six groups include planning using sociotechnical analyses,²⁴ academic detailing as an education strategy, financial incentives for use of clinical decision support (e.g., meaningful use), use of checklists as a restructuring strategy,³⁰ audit and feedback of imaging use as a quality strategy,³¹ and tort reform as a policy strategy. ED studies fitting into the planning strategy category are infrequently undertaken, but would have the benefit of obtaining buy-in from stakeholders invested in the local implementation of imaging clinical decision instruments (such as hospital safety and risk officers). The list of 68 discrete implementation strategies (in the six groups) provided by Powell et al. allows investigators to consider studying strategies separately, as multifaceted interventions (e.g., focused education combined with audit and feedback) or as blended approaches. Studies of blended strategies (e.g., implementation toolkits that package multiple strategies into one protocol) should address and report local sites’ needs and context to offer experience to others attempting similar dissemination and implementation interventions.^{32,33}

When implementing intervention strategies to optimize diagnostic imaging, three general types of outcomes can be measured: clinical (patient) outcomes, implementation outcomes (e.g., fidelity, penetration, sustainability), and service outcomes (such as efficiency and timeliness).²⁹ An evaluation of these outcomes concurrently allows investigators to better understand why an intervention may have failed; was it the intervention itself or some aspect of the implementation process?^{34–37} Acceptability of an intervention to relevant stakeholders is essential to success and, along with perceived appropriateness of an intervention, is best evaluated with questionnaires, surveys, interviews, and focus groups. Adoption, or uptake, can be at the provider or organization level and can be measured with mixed methods. Penetration refers to the proportion of providers using an intervention or the number

of eligible patients for whom an intervention was used, both of which require rigorous measurement approaches. Incremental cost of an implementation will depend on three factors: the cost of the intervention (e.g., a CT scan), the complexity of the implementation strategy, and the health care setting itself. Feasibility, or the extent to which a new initiative can be successfully carried out within a health care setting (such as the ED), is usually studied retrospectively and often depends on the resources available for implementation. Fidelity, or the extent to which the implementation of an intervention is true to the way the intervention was derived and validated, can be evaluated by determining adherence to protocols. It will be essential for researchers to extend beyond the studying of objective clinical outcomes (e.g., ordering rates) and focus additionally on implementation outcomes such as acceptability, appropriateness, adoption, cost, feasibility, fidelity, penetration, and sustainability.

To maximize the benefits of dissemination and implementation methodology on ED imaging utilization, our group recommended the following specific research questions:

1. Which conceptual frameworks are most relevant and useful for understanding the local clinical and institutional context, adapting an evidence-based intervention to that context, selecting relevant implementation strategies, and conducting a multifaceted evaluation?
2. What is the comparative effectiveness of the following strategies on ED imaging utilization?
 - Multidisciplinary/locally adapted guideline implementation
 - Audit and feedback
 - Provision of clinical decision support systems
 - Computerized order entry with point-of-care feedback
 - Physician education on clinical decision-making

Research Question 3: What interventions at the health care policy level can facilitate adoption of evidence-based interventions for ED imaging?

A number of interventions at the health care policy level may facilitate adoption of evidence-based interventions for ED diagnostic imaging. Here, we will focus on four that require investigation regarding their effects: quality measures, government and professional society guidelines, legislation, and malpractice reform.

Quality measures, often accompanied by public reporting and financial implications, are commonly used in an attempt to alter practice patterns. Such measures may present opportunities to improve uptake of evidence for ED imaging. Imaging-related measures that are provisionally endorsed by the National Quality Forum (NQF) that could be used in this fashion include sonographic determination of pregnancy location for pregnant patients with abdominal pain (NQF #0651), and inappropriate pulmonary CT imaging for patients at low risk for pulmonary embolism (NQF #0667). Measures such as these require testing

and validation. It is critical that the EM community be involved in measure development to assure their appropriateness and validity. If not, problematic measures may be advanced.^{38,39} Measures can be strengthened when they consider and include evidence-based policies from national EM groups.

Imaging guidelines developed by government agencies and professional societies could potentially facilitate adoption because of their widespread dissemination and awareness by practitioners, as well as the authority of the source. One successful recent example of widespread professional society imaging guideline dissemination is the American Board of Internal Medicine Foundation's Choosing Wisely campaign (<http://www.choosingwisely.org/>), which has been adopted by over 60 U.S. professional societies. The American College of Emergency Physicians compiled a list of 10 practices that should be questioned as potentially unnecessary by patients and their physicians, five of which involve ED imaging: chest CT for suspected pulmonary embolism, head CT for select patients with blunt head trauma, head CT for syncope with an unremarkable neurologic examination, lumbar spine imaging for patients with acute back pain, and renal CT for suspected kidney stone.⁴⁰ However, the actual effect of this type of initiative on ordering behavior is unclear. One study from the United Kingdom found that compliance with the National Institute for Health and Care Excellence (NICE) head injury guidelines was excellent in adult patients, but quite poor in pediatric patients.³⁴ Another study of the NICE guidelines for imaging after urinary tract infections found mixed adherence⁴¹ and North American authors found that governmental guidelines for MRI in low back pain resulted in only modest (if any) change in image ordering practice.⁴²

In addition to the development of quality measures and imaging guidelines, governmental agencies may attempt to increase the adoption of evidence-based imaging practices by simply mandating their use. Recently, the U.S. Congress did exactly this. As part of the Protecting Access to Medicare Act of 2014, they legislated that EDs (in addition to other hospital settings) must use "applicable appropriate use criteria for applicable imaging services only from among appropriate use criteria developed or endorsed by national professional medical specialty societies or other provider-led entities."⁴³ This mandate requires the Secretary of Health and Human Services to determine which "appropriate use criteria" will be allowable, noting that these criteria should have stakeholder consensus, be scientifically valid, and be based on studies that are published and reviewable. If chosen correctly, these criteria may facilitate adoption of imaging guidelines. Future research in this area might focus on effective methods for increasing physician awareness of imaging-related policies (including quality measures, legislation, and government/specialty-specific guidelines), as well as the direct and indirect effects of these policies on imaging practices.

There is some evidence to suggest a link between fear of malpractice and the ordering of unnecessary imaging,⁴⁴⁻⁴⁶ while other studies have not shown this association.⁴⁷ Many EPs believe that meaningful malpractice reform might decrease the number of unnecessary imaging studies.¹⁷ However, a recent study found this not to be the case: states with recently passed tort reform did not exhibit a significant decrease in imaging studies ordered by EPs, compared to control states.⁴⁸ More research would be needed to confirm the results of this single study with only 7 years of follow-up. Furthermore, certain physician personality

traits (e.g., stress from uncertainty and risk tolerance, rather than fear of litigation) have been identified as playing a role in the decision to order imaging studies.⁴⁹ Future research in this area might involve mixed-methods approaches, including structured interviews with physicians practicing pre- and post-tort reform in order to better understand its effect on their practice. A more granular understanding of the specific facets of tort reform that might affect practice (ease of bringing lawsuits, caps on monetary awards, etc.) may better inform reform initiatives.

To better understand the interplay between dissemination and implementation and health policy interventions, our group recommended research to address the following specific questions:

1. What strategies can effectively close the gap between emerging health care policy and best evidence available pertaining to ED imaging?
2. How does health care policy affect physicians' and institutions' incentives with regard to imaging utilization in the ED?
3. How do policy interventions compare with "grass-roots" initiatives (at the departmental or institutional level) to reduce unnecessary imaging?
4. What are the barriers to the development of effective evidence-based quality measures?

Research Question 4: How can health information technology, including electronic health records, clinical decision support, and health information exchanges, be used to increase awareness, use, and adherence to evidence-based interventions for ED imaging?

Health information technology has the potential to improve quality and efficiency while also increasing observance of care guidelines and decreasing errors.⁵⁰ Electronic health records (EHR) are expected to improve care, advance safety and decrease costs.⁵¹⁻⁵³ Clinical decision support systems, computerized provider order entry (CPOE), and health information exchanges are considered to be some of the most vital aspects of EHRs⁵⁴ and can facilitate decision-making in the ED. Decreases in the utilization of certain imaging modalities have been attributed to improved adherence to clinical practice guidelines and implementation of health information technology interventions.^{55,56}

Clinical decision support systems are designed to improve provider decisions. When well designed and implemented, clinical decision support systems can improve patient safety, clinical workflow, guideline adherence, and quality of care.^{42,50,57-63} Evidence suggests that clinical decision support systems may also decrease malpractice events.⁶⁴ Clinical decision support systems are expected to reduce unnecessary imaging by providing guidelines and appropriateness criteria for imaging.^{65,66} Adherence to imaging guidelines is associated with more appropriate diagnostic imaging usage⁶⁷⁻⁶⁹ and evidence supports the superiority of electronic clinical decision support systems to paper.^{70,71}

ED-based research also supports the value of clinical decision support systems to reduce unnecessary imaging. Raja et al.⁷² demonstrated that a clinical decision support systems intervention decreased the inappropriate use of CT in patients with suspected pulmonary

emboli. Another study demonstrated a reduction in unnecessary head CTs and improved adherence to guidelines in mild traumatic brain injury.⁷³

However, despite the positive qualities of clinical decision support systems, some research demonstrates a low rate of clinician behavior adjustment. Curry et al.⁷⁴ found that 24% of imaging studies in the primary care setting were identified as inappropriate by a clinical decision support system with integrated best-practice prompting. Of these, only 25% of the orders were modified to follow practice guidelines. Workflow integration was cited as the main issue in compliance with the clinical decision support system prompting; appropriate integration into workflow is of the utmost importance for successful adoption.⁷⁵ Case-based simulation and usability testing of clinical decision support systems should be undertaken with major EHR vendors.

While EHRs are capable of reducing duplicate testing in a single institution, patients who visit multiple clinical settings run the risk of missing clinical data from their previous encounters.⁷⁶⁻⁷⁸ Health information exchange creates interoperability between health care systems⁵⁴ and with this comes many potential benefits including reductions in cost and improvements in quality and safety.⁷⁹⁻⁸⁵ Health information exchange has been shown to reduce unnecessary testing,⁸⁵⁻⁸⁷ and there is some evidence that it may reduce unnecessary imaging studies.^{82,83} Reductions in cost from decreased medical imaging and other tests are projected to be substantial.⁸⁸ However, few studies have examined the rate at which unnecessary duplicative imaging studies are being performed across an exchange. While evidence suggests that health information technology can improve imaging utilization, there are many barriers to complete integration and use. Physician knowledge and familiarity with guidelines affect usage.⁵⁴ Studies have suggested that those who do not follow clinical decision support systems may be less likely to follow guidelines overall.⁸⁹ An overall lack of established practice and imaging guidelines leads to an inability to create adoptable and integrated clinical decision support systems,⁵⁴ and ambiguous elements of guidelines are difficult to implement into electronic systems.⁹⁰

Barriers to fully realizing the benefits of health information exchanges for imaging studies exist, including the lack of mapping imaging study names to standard terminologies, making measurement, and alerting across sites impossible.^{91,92} We propose research to promote the use of standard terminologies for imaging studies, measurement of potentially avoidable duplicate studies performed across sites in a health information exchange, and the development of duplicate imaging alerts based on health information exchange data.

While the goal of medical imaging health information technology is to aid in appropriate utilization in the ED, unintended consequences do exist. Although clinical decision support systems can improve adherence to guidelines, this can lead to unexpected results. The American Headache Society and American College of Radiology both make Choosing Wisely recommendations to avoid neuroimaging in patients with stable or uncomplicated headaches.^{93,94} However, Hawasli et al.⁹⁵ found in a small retrospective review that between 3 and 7% of the patients they studied might have had delayed or missed diagnoses of brain tumor if these guidelines had been adhered to.

Although CPOE systems are designed to improve order entry, they have as an unintended consequence increased the time required to enter imaging orders, leaving less time for clinicians to spend at the bedside.⁹⁶ This time cost may be offset by more detailed information (e.g., clinical practice guidelines, clinical decision instruments) being made available to clinicians at the point of care.^{96,97} Additional unintended consequences of CPOE include negative effects on workflow; requirements for the implementation and upkeep of new systems; changes in the way physicians communicate; new kinds of errors including omissions, wrong patient orders, and desensitization to alerts; and a new dependence on technology with poor productivity during downtime.⁹⁷ Overall, EPs are clearly interested in understanding to what degree clinical decision support can safely and efficiently reduce unnecessary imaging.⁹⁸

To fully realize the potential of such interventions, our group recommended the following specific research questions:

1. What are the optimal ways to integrate imaging clinical decision support systems into the EHR? Specific questions include:
 - At what points in the workflow entry should decision support be provided for specific clinical situations?
 - What trigger mechanisms capture appropriate patients but minimize alert fatigue within clinical decision support systems?
 - What data entry methods can be used to effectively drive clinical decision support systems (e.g., is forced checkbox entry necessary; what is the role of patient data entry)?
 - How can existing EHR information, including clinical data, be optimally integrated into clinical decision support systems to improve imaging utilization?
 - How can guidelines be integrated effectively into clinical decision support systems?
2. What are the best technical approaches to integrating health information exchange-based imaging data into EHR systems?
3. How often are unnecessary duplicative imaging studies performed across a health information exchange?

CONCLUSIONS

The recent rise in ED diagnostic imaging rates, combined with lack of evidence to suggest an associated improvement in clinical outcomes, suggests that there exists a large potential to improve imaging utilization. Given the robust body of evidence that exists to aid clinicians in appropriate image ordering, it is critical to address its dissemination and implementation. In this article, we have compiled and discussed four overarching research endeavors, with corresponding specific research questions. We believe these are essential

to determine how we can maximize the positive effects of evidence-based interventions on decreasing unnecessary ED imaging while delivering safe, high-quality patient care.

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