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longitudinal tracking of learners and their curricular and assessment information from medical school through residency and practice. With such systems, innovations in medical education could not only measure learner outcomes but also determine how that learning is influencing care (ie, how the learning is being applied and translated). Acknowledging that these will be complex systems with possibly nonlinear relationships between processes and outcomes, we need to complement our armamentarium of research designs with qualitative methods, mixed methods, and social science methods.

The transition to outcome studies for medical education will require new epidemiology, new funding, and a new mindset; and it will require patience. In the meantime, the communities at the 2 ends of the educational spectrum can do better to understand each other and collaborate. For medical educators this means making better efforts to raise the level of research design: more RCTs, more multicentered collaborative education research, higher-order outcomes, and outcomes that are more closely as-

sociated with patient-centered outcomes. For the clinical epidemiologists it means being open to more proximal outcomes (eg, learner-centered outcomes that have strong linkage to patient-centered outcomes, to patient satisfaction, quality of interactions, and quality of decision making); considering more qualitative methods to address the human interactions of the learner-patient experience; understanding the unique challenges of education research; and appreciating its social science nature.^{9,10} For policy makers, we need to invest more resources in both realms in order to better understand what we do and how we can do it better and more efficiently.

The JAMA Network has shown a strong commitment to support publishing patient-centered educational research, and will continue to do so. The study of how to best teach the practice of Medicine is as important as the study of how to best practice medicine. Aligning these missions more closely will not only improve the practice of medicine, but also the care of patients.

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Imaging More Wisely

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The right imaging tests performed at the right time can lead to earlier and more accurate diagnoses, better treatment decisions, and improved patient outcomes. Unnecessary and inappropriately performed tests harm patients by causing them discomfort and anxiety, by leading to a large number of irrelevant incidental findings, and by exposing them to ionizing radiation that can have harmful effects on their health. We waste approximately \$30 billion annually on unnecessary imaging tests in the United States.¹

In 2012, the American Board of Internal Medicine Foundation launched the Choosing Wisely initiative to advance a

national dialogue on avoiding wasteful or unnecessary medical tests, treatments, and procedures.^{2,3} The American College of Radiology followed suit by launching the Image Wisely campaign, which calls for eliminating unnecessary imaging and using the minimum amount of radiation needed to perform an indicated test.⁴ Three studies in this issue of *JAMA Internal Medicine* underscore the need for additional strategies to achieve these goals.

In one study, Drescher and Sirovich⁵ found that the rates of computed tomographic (CT) scanning for patients visiting an emergency department with respiratory symptoms quadrupled between 2001 and 2010. Imaging increased in every severity group but rose most steeply among patients with low-acuity symptoms (such as those



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with nasal congestion), who are the least likely to benefit from such testing. The authors found no measurable health benefits of greater CT scan use and concluded that a great deal of the increase in the use of CT scanning in the emergency department is unnecessary.

Two other research letters in this issue, both by Mercuri et al,^{6,7} suggest that our problems in the use of imaging studies are not just the increasing rate of unnecessary tests but also the marked variation in how safely the tests are performed. The focus of their investigation is myocardial perfusion imaging (MPI), which is the most common imaging test used in the United States for diagnosing coronary artery disease and accounts for approximately 20% of the total annual medical radiation to which patients are exposed.⁸

In one study, Mercuri et al⁶ showed that the use of radiation varied markedly across the United States and that only 14% of US facilities were within the quality benchmark compared with 32.6% of facilities in 64 other countries. A typical US patient received a radiation dose for an MPI test that was on average 20% higher for the same test performed in the 64 other countries. There is no obvious benefit of using higher radiation doses to perform this test. In addition, the harm of the higher radiation dose per MPI test in the United States is compounded by our markedly greater use of this imaging test compared with other countries. In a related analysis, Mercuri et al⁷ also found that the rates of stress-first imaging, which uses a lower radiation dose, are far lower in the United States than in other countries (7.7% in North America vs 84.4% in Europe). Adopting a practice of stress-first imaging among patients undergoing MPI in the United States could result in a dramatic decrease in the average radiation dose without loss of clinical information. The variation in radiation dose in the performance of MPI is consistent with what data have previously been reported for CT scans.⁹

There are many reasons why the use of imaging has grown over time and why there is variation in the amount of radiation delivered when these tests are performed. Clinical management has increasingly come to rely on CT scans and other imaging tests as the technical quality and speed of imaging have improved. There has been an annual growth of around 8% in the use of CT scans in the past decade,¹⁰ but the growth in the availability of CT scans has not been matched with a system of accountability. Physicians independently decide when to order tests and determine how they are performed. There is little oversight of the quality of their decisions or penalties for their overuse or misuse of imaging studies. The lack of explicit and enforceable radiation standards for most imaging studies and the lack of transparency on how much radiation a patient receives when undergoing a diagnostic test undermines accountability.

Overuse and misuse of imaging tests are also predictable symptoms of a fee-for-service payment system that incentivizes volume over value. Adding a CT scan to an emergency department visit can double Medicare's reimbursement for that visit.¹¹ The multistudy MPI approach most frequently used in the United States is associated with a 30% higher rate of Medicare reimbursement than the lower-dose stress-only imaging. To change the rate of use and the radiation doses associated

with imaging tests, we must realign the incentives in our fee-for-service system to reward quality rather than quantity.

Congress has recognized the shortcoming of the fee-for-service payment model and earlier this year created the Medicare Incentive Payment System, which will soon place Medicare physicians at financial risk for their practice style. Physicians will be able to choose to either have their Medicare payment affected by how their performance compares with that of other Medicare physicians or to join organizations, such as accountable care organizations (ACOs), which accept financial risk for a defined population of patients. When physicians choose to have their performance judged against that of other Medicare physicians, they will have 4% of their reimbursement at risk based on their performance beginning in 2019; this percentage will increase to 9% by 2022. Physicians participating in ACOs will need to reduce their cost of care to share in any savings. To receive shared savings, ACOs must also demonstrate that they meet or exceed specified performance targets.

The quality metrics on which physicians will be judged as a part of the Medicare Incentive Payment System pay-for-performance program are in the process of being developed. Medicare could achieve significant cost savings and contribute to a reduction in unnecessary and harmful radiation by making the safe and appropriate use of expensive imaging tests, such as CT scans and MPI, part of its performance measures. Such an approach would be relevant for a wide range of physicians, and it could lead to rapid improvements in costs and safety. A separate but related effort should be made to create performance metrics for radiologists and others performing imaging studies to ensure that they perform these tests within specified standards of minimally required radiation doses.

At present, none of the Medicare ACO performance measures relate to the appropriate use of imaging studies, but the Centers for Medicare & Medicaid Services could mimic the same approach proposed for the Medicare Incentive Payment System pay-for-performance program by adopting the same measures at the population level for the ACO.

The work of developing quality measures for imaging tests needs to be done in a patient-centered way and in collaboration with patients, those who understand the clinical appropriateness of imaging studies, and those who understand the risks of using the tests and how to reduce those risks. Patients are the ones who these tests are designed to help, and their viewpoints on the value they place on different outcomes must be incorporated into every measure.^{12,13} Patients care about avoiding radiation where possible.¹⁴ Referring physicians can contribute important judgments to these performance metrics regarding when imaging studies are unnecessary because they are unlikely to change practice. They can also reinforce patients' expectations that the potential benefits of an imaging study must be balanced against the potential harms of unnecessary anxiety and exposure to ionizing radiation. Radiologists have an important role to play in developing performance metrics by informing physicians about the best test option, when tests are likely to yield important as well as incidental results, and what is practical with respect to minimizing radiation exposures while ensuring accurate diagnoses.

While clinical judgment is an important starting place, the process for the establishment of performance measures must be evidence based. Existing decision support tools for medical imaging tests rely largely on the appropriateness criteria developed by the American College of Radiology that are primarily based on expert opinion. These criteria have not reduced the use of inappropriate imaging tests¹⁵ or improved the safety of imaging studies, in large part because their criteria, while a step in the right direction, do not go far enough in explicitly stating that imaging tests are not necessary even when the data clearly support this conclusion. For example, the American College of Radiology appropriateness criteria for acute sinonasal disease states that most cases of uncomplicated acute rhinosinusitis are diagnosed clinically and do not require imaging tests.¹⁶ Nonetheless, the American College of Radiology rates imaging with CT scan for this clinical condition with an appropriateness score of 5 out of 9, suggesting that a CT scan may be appropriate, instead of giving it a much lower value to reflect the reality that such imaging tests are generally not appropriate in this clinical context.

In the near future, physicians will be required by the Protecting Access to Medicare Act to consult appropriate use criteria (decision rules) before ordering and billing for advanced diagnostic imaging tests for Medicare patients. Improving the quality of the recommendations in these decision support tools could potentially have a significant effect on the appropriate use of imaging and patient safety.

To date, much of the work in the Choosing Wisely campaign has been done within silos (individual management systems that do not operate with any other system). For example, the Imaging Wisely recommendations were developed within radiology. When it comes to medical imaging tests, it is time for physicians who order the tests to join together with radiologists and other physicians who perform imaging studies to form a consensus guided by patients' values about the pressing need to perform imaging tests more wisely. The establishment of meaningful measures of performance in combination with payment reform offers the best hope of improving the value and safety of medical imaging studies.

ARTICLE INFORMATION

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