Misuse and overuse of medical imaging have gained widespread attention due to rising costs, radiation exposure risks, and limited comparative effectiveness evidence. Involving patients in shared decision making offers an opportunity to more clearly define risks and benefits, thus allowing patients to consider both personal values and the best available evidence.

Over the past 2 decades, the medical imaging industry has experienced considerable technological innovation and growth. A retrospective analysis of advanced diagnostic imaging at 6 large integrated health systems for the 15-year period 1996–2010 showed annual increases of 7.8% for use of computed tomography (CT), 10% for use of magnetic resonance imaging (MRI), and 3.9% for use of ultrasound [1]. During the 12-year period 1996–2007, the number of CT scans performed during emergency department visits increased 330% [2]. The reasons for ordering CT scans in the emergency department are complex and multifactorial; ordering rates are notably higher for patients being assessed for abdominal pain, flank pain, chest pain, or shortness of breath. Concern over the increased use of CT scans in pediatrics is especially apt, because children are more susceptible to the effects of radiation than are adults [3]. CT, MRI, and ultrasound are responsible for much of the increased use of imaging, but utilization rates for nuclear medicine and angiography/fluoroscopy are also on the rise [4, 5]. Although the total cost of medical imaging to the health care system cannot be readily determined, an analysis of Medicare costs estimated that $14 billion was spent on diagnostic imaging in 2006, which was double the amount spent just 7 years earlier [6].

Although the use of medical imaging is widely credited with earlier and more accurate diagnoses, there are few comparative effectiveness studies defining the benefits and risks of medical imaging across different applications and settings. The misuse and overuse of medical imaging has gained increased national attention in recent years, in part due to the unsustainable pace of health care spending and because of data linking the risk of cancer with the radiation received during medical imaging [7]. Increased use of CT scans has increased radiation exposure such that the mean per-capita effective dose roughly doubled from 1996 through 2010 (increasing from 1.2 millisieverts [mSv] to 2.3 mSv) [1, 8]. During the same time period, the proportion of enrollees who received high (>20–50 mSv) annual radiation exposure also doubled (increasing from 1.2% to 2.5%), as did the proportion of enrollees who received very high (>50 mSv) annual radiation exposure (increasing from 0.6% to 1.4%) [1]. In 2010, 6.8% of patients who underwent imaging received high annual radiation exposures, and 3.9% received very high annual exposures [1]. At current levels of exposure, it is estimated that about 2% of all future cancers in the United States will be attributable to radiation exposure from CT scans [1, 8].

The root causes of the overuse and misuse of medical imaging are multifactorial and include patient, provider, and health system influences. From a health system standpoint, a fee-for-service reimbursement structure encourages increased utilization. This trend is compounded by a paucity of comparative effectiveness studies and evidence-based guidelines, leading to a lack of standardization and poor adherence to the guidelines that are available. However, studies suggest that 20% to 40% of CT scans could be avoided if providers followed existing evidence-based clinical guidelines [9, 10]. Real or perceived threats of medical malpractice suits result in the practice of defensive medicine, which may cause providers to order unnecessary imaging studies. Additional factors contributing to overuse of imaging include providers and patients not being fully informed about the risks and benefits of testing, as well as not being fully informed about the sensitivity, specificity, negative predictive value, and positive predictive value of the test being considered. Finally, patients often initiate requests for imaging because of their perception that it will provide a benefit, and providers frequently will order an imaging study when prompted by a patient to do so, even if they feel the test will provide no value [5].

One study at a large, urban academic medical center [11] found that utilization of imaging studies was associated...
both with the number of provider visits and with patient demographic characteristics. The number of primary care provider visits strongly influenced both the probability that imaging would be performed and the amount of imaging that was performed. A direct correlation was also found between specialist visits and the use of imaging. The patient demographic factors that positively influenced utilization of imaging were race/ethnicity (African American or Hispanic) and sex (female) [11]. Physician factors were also found to contribute significantly and substantially to imaging utilization. The physician’s years of experience, sex (female), foreign medical graduate status, and whether he or she had another professional degree were all factors that had a positive effect on the probability that imaging would be ordered. One notable factor that did not reach statistical significance for either probability or amount of imaging was the number of malpractice claims against the physician [11].

Spine imaging for lower back pain is a common example of overuse and inappropriate use of imaging. There is little in the way of evidence or expert opinion to support claims that such imaging is beneficial [5, 12], and it seldom changes management; the yield of unexpected findings on plain radiographs of the lumbar spine is reported to be as low as 1 in 2,500 [13]. More alarming is the risk of incidental findings of unknown clinical relevance. When MRI scans were performed on adults with no history of back pain or sciatica, 22% of individuals younger than 60 years were found to have herniated discs [14]. In adults older than 60 years, 57% were found to have herniated discs (36%) or spinal stenosis (21%) [14].

Spine imaging in patients without any indication of underlying systemic disease or major neurologic compromise does not appear to improve patient outcomes [5]. Furthermore, simply knowing that a spinal abnormality was incidentally found on imaging leads to more reported pain and less improvement in the patient’s self-rated general health. Evidence also suggests that imaging might drive subsequent decisions to operate. Studies of geographic variation show that spine surgery rates directly correlate with spine imaging rates. Thus it appears that imaging has the potential to diminish patients’ self-perceptions of their health and may drive potentially unnecessary visits and surgery, even though imaging findings may be of dubious clinical importance [5].

The high costs of imaging and the potential risks—cancer, incidental findings, and other harms—have prompted efforts to better document the value of imaging and to eliminate services that clinical guidelines deem to be unnecessary. However, these efforts are not comprehensive. Guidelines or other best-practice measures should optimize the use of imaging by ensuring that patients receive imaging studies that are indicated and avoid those that are unnecessary [15]. Benefits should be quantified, and evidence-based guidelines should be developed that clearly balance the benefits of imaging against financial costs and health risks.

In light of the growing recognition of imaging overuse and misuse, many medical societies—including the American Academy of Allergy, Asthma and Immunology; the American College of Cardiology; and the American College of Radiology—have made recommendations regarding when not to order commonly overused tests and procedures. For example, there are recommendations that physicians not order CT scans for uncomplicated acute sinusitis; imaging for lower back pain within the first 6 weeks of pain; stress cardiac imaging or coronary angiography in patients without signs or symptoms or cardiac disease, unless other markers indicate high risk; imaging for uncomplicated headache; imaging for suspected pulmonary embolism, unless the pretest probability of pulmonary embolism is moderate or high; and positron emission tomography (PET), CT, or radioisotope bone scans in the staging of early prostate cancer [16, 17].

There has been increasing demand that clinicians improve communication and the quality of the patient experience [18], and this demand extends to physicians’ decisions regarding imaging. Brief patient education can help to improve patient satisfaction when imaging is not recommended [19]. Avoiding imaging may itself be part of this education: When radiography was performed for low-risk patients with back pain, they were more likely to expect such imaging in the future [19]. Research suggests that informed decision making improves patient knowledge about treatment and management plans and also improves satisfaction with the clinical encounter. Finally, studies show that wider adoption of informed decision making has the potential to reduce costs. As many as 20% of patients who participate in decision making choose less invasive surgical options and more conservative treatment compared with patients who are not exposed to decision aids [20].

The risk of developing cancer or other radiation-induced diseases as a result of medical imaging must be balanced against the potential benefit of improved diagnostic accuracy. Although patients’ understanding of the potential benefits and harms of personal choices relating to imaging could lead to improved medical decision making, there is little research on this topic. Nonetheless patients should be informed of the potential benefits and harms of imaging and should be allowed to participate in informed decision making [21].

The utility of imaging, like that of other medical tests, depends on the treatability of the underlying medical condition. Additional risk from medical imaging, especially imaging involving high-energy radioactivity, should be undertaken only when the benefits outweigh the harms. This can only occur when the imaging study has a reasonable chance of finding a condition that will benefit from intervention. If there is low probability of the condition being modifiable, then the impact of the test will likely be negligible, and consequently, the risk of the test will be unjustifiable. Conversely, if there is already a high degree of certainty that
the patient has a modifiable condition, then the risk of the test is also unjustifiable. As research moves forward, the goal is to improve estimation of benefits and harms, leading to better decisions.

Decision aids are sources of evidence-based health information that can help patients make informed treatment decisions. Effective decision aids should increase knowledge, make risk communication more interactive, and more effectively identify patient values. Moreover, use of decision aids helps more patients to be actively involved in the decision-making process; such changes are essential to improving patient adherence to medical therapies [22, 23]. Currently, medical offices face challenges in accessing decision aids that are appropriate for specific diseases or conditions, but mobile, tablet, and Internet technologies have great potential for improving accessibility.

Patients should understand that radiation-based imaging studies should only be performed when the information to be gained justifies the potential harm. Decision making about medical imaging should include a thorough conversation between patients and their doctors regarding the benefits and risks of the procedure. Little research is currently available on how best to involve patients in the complex process of deciding whether to use medical imaging, and development of decision aids is challenging due to lack of evidence that imaging results in quantifiable improvement in patient outcomes. Thus more research and additional decision aids are needed to improve and simplify patient education and decision negotiation. NCMJ

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Acknowledgment
Potential conflicts of interest. All authors have no relevant conflicts of interest.

References