

# Inappropriate Ordering of Lumbar Spine Magnetic Resonance Imaging: Are Providers Choosing Wisely?

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Most Americans will experience low back pain (LBP) at some point in their adult lives.<sup>1</sup> Many patients with LBP receive imaging to explore the cause of their pain<sup>2</sup>; advances in imaging technology have revealed unprecedented anatomical detail for LBP patients. The underlying difficulty is that, for many patients, anatomical and functional abnormalities do not correlate well, and thus imaging can fail to guide treatment of the primary complaint.<sup>3-8</sup> In one study of individuals who underwent magnetic resonance imaging (MRI), approximately 90% were detected to have a degenerated or bulging disc, 36% had a herniated disc, and 21% had spinal stenosis—but all patients were asymptomatic.<sup>4</sup> For most patients, LBP resolves on its own<sup>9-10</sup>; even sophisticated imaging of the lumbar spine (LS) for nonchronic pain does not improve outcomes.<sup>11</sup>

Overuse of LS MRI is suspected to be a large problem; multiple societies have prioritized it as a quality-of-care measure or a measure of prudent stewardship of resources. The American College of Physicians and the American Association of Neurological Surgeons recommend against the use of LS MRI for nonspecific or nonpersistent LBP in their Choosing Wisely campaign.<sup>12,13</sup> The National Quality Forum (NQF), a nonprofit entity that sets national priorities for quality measurement, has endorsed a CMS measure regarding inappropriate use of imaging in LBP.<sup>14</sup>

The reasons for overuse of imaging are not well understood. Fee-for-service financial incentives have been suggested as a potential reason for overuse of lumbar spine imaging,<sup>15</sup> as have malpractice concerns<sup>16</sup> and cultural factors.<sup>17</sup> In this study, we explored inappropriate use of LS MRI in a US healthcare system—one largely free of financial incentives for overuse, and in which physicians are largely insulated from malpractice concerns—to understand whether inappropriate ordering occurs in the absence of these financial or legal influences. The federal government accepts liability for any instances of medical

## ABSTRACT

**Objective:** To analyze inappropriate use of magnetic resonance imaging (MRI) for patients with low back pain in a healthcare system with no financial incentives for overuse.

**Study Design:** We used administrative data to assess the appropriateness of lumbar spine (LS) MRI in the Veterans Health Administration.

**Methods:** All veterans who received LS MRI in the outpatient setting in fiscal year 2012 were included. We based our assessments of appropriateness on CMS criteria, which have been endorsed by the National Quality Forum. Generalized estimating equations were used to evaluate characteristics of inappropriate scans.

**Results:** Of the 110,661 LS MRIs performed, 31% were classified as inappropriate. Most scans that were considered appropriate were characterized as such because they were preceded by conservative therapy (53%). "Red flag" conditions were responsible for a much smaller percentage of scans being considered appropriate; 13% of scans were preceded by conservative therapy and were performed in patients with a red flag condition, while only 4% of scans were considered appropriate because of red flag conditions only. Scans ordered in the emergency department and in urgent care, primary care, and internal medicine clinics were most likely to be classified as inappropriate. Resident physicians were significantly less likely than other provider types to order inappropriate LS MRIs (odds ratio, 0.80;  $P < .0001$ ). Approximately 24% of providers ordered 74% of inappropriate scans.

**Conclusions:** We found that 31% of LS MRIs were inappropriate in a healthcare system largely absent of financial and other incentives for ordering. The problem of inappropriate ordering of LS MRI is concentrated in a small number of providers; any provider-facing interventions to reduce inappropriate order should therefore be targeted, rather than aimed at all providers who order LS MRI.

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negligence or wrongdoing on the part of the Department of Veterans Affairs (VA) providers; concerns over malpractice or incentives to practice defensive medicine are therefore much lower for VA providers compared with providers in the larger US healthcare environment. It is also not well understood whether inappropriate ordering is equally distributed across providers, or concentrated among relatively few high-ordering providers; this information carries important implications for quality improvement activities. Here, we use NQF-endorsed CMS criteria to evaluate inappropriate ordering of LS MRI across the entire VA, including the patient-, provider-, and system-level factors associated with the practice.

## METHODS

To study the appropriateness of this imaging modality, we identified the population of veterans who received an outpatient LS MRI in VA in fiscal year (FY) 2012. If patients received more than 1 LS MRI, we retained information regarding the first MRI. Additionally, we searched VA inpatient and outpatient data from FY 2010 to FY 2012 to evaluate the care and condition of these veterans prior to receipt of LS MRI. CMS criteria pertain to LS MRIs with a diagnosis of LBP on the MRI claim; because VA MRIs do not have associated diagnosis codes, we evaluated all LS MRIs. We considered the clinic visit with the ordering provider that immediately preceded the scan to be the ordering visit.

We evaluated the appropriateness of LS MRI according to the NQF-endorsed CMS measure #0514 (“MRI Lumbar Spine for Low Back Pain”),<sup>14</sup> with slight modifications (**Figure**). This measure classifies an LS MRI as appropriate if it was: 1) preceded by conservative therapy, or 2) conducted in a patient who has a “red flag” condition. CMS considers physical therapy or chiropractic care in the 60 days prior to the scan, or an evaluation and management visit occurring between 28 to 60 days prior to the scan, to be conservative therapy. Physical therapy, chiropractic care, and evaluation and management visits were identified by Current Procedural Terminology codes specified by the NQF-endorsed CMS measure.<sup>14</sup> We classified an evaluation and management (E&M) visit as conservative therapy only if the scan was not ordered during that visit.

We made minor modifications to the CMS criteria regarding red flag conditions. The CMS measure excludes LS MRIs occurring in patients with red flag conditions from the denominator; here, we included them but con-

### Take-Away Points

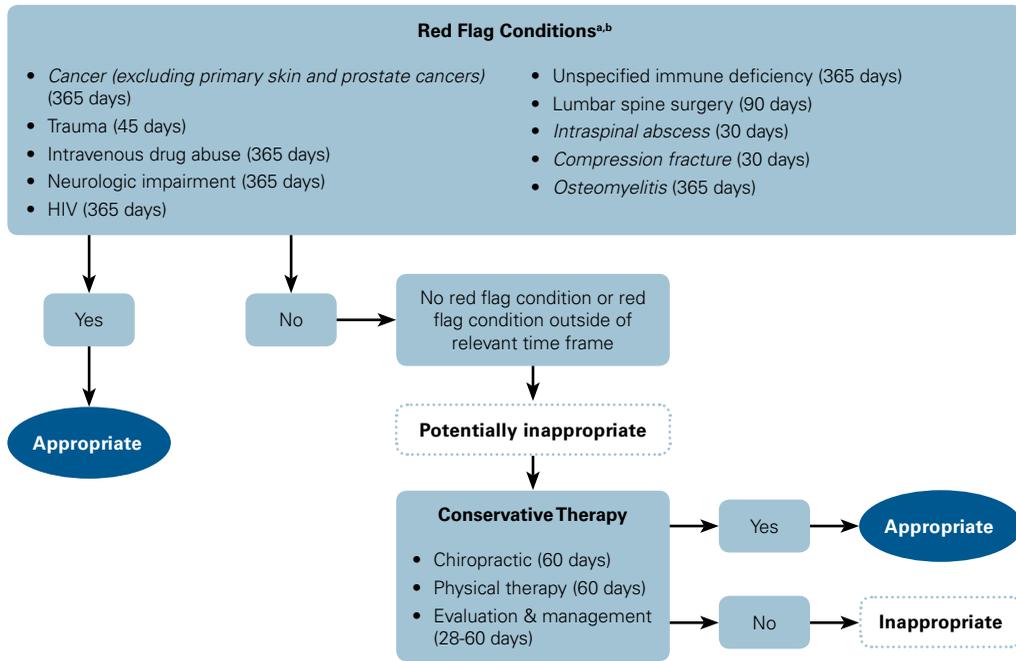
Using CMS criteria, we found that 31% of lumbar spine magnetic resonance imaging (LS MRI) performed in fiscal year 2012 was inappropriate. This high level of inappropriate ordering is particularly striking in a system largely free of financial and other incentives for ordering, suggesting that nonpecuniary factors play a role in these inappropriate ordering choices. We found a high concentration of inappropriate ordering among few providers. Results indicate that efforts to reduce inappropriate use of LS MRI should involve cultural change, as well as patient and provider education, rather than financial incentives alone, and that provider-facing efforts should be targeted instead of universal.

sidered them to be appropriate in order to present a complete view of all LS MRIs in VA. CMS red flag conditions include trauma in the 45 days preceding the scan; LS surgery in the 90 days preceding the scan; or intravenous drug abuse, neurologic impairment, cancer, HIV diagnosis, or diagnosis of unspecified immune deficiency in the 365 days preceding the scan. The measure includes all cancer; we excluded primary skin and primary prostate cancer as these types of neoplasms would not cause lumbar compression and rarely have an impact on spine pain. Additionally, there are concerns regarding a high false-positive rate for prostate cancer due to overuse of prostate-specific antigen (PSA) screening. To the CMS red flag conditions, we added intraspinal abscess or compression fracture in the 30 days prior to the scan, and osteomyelitis in the previous 365 days. All red flag conditions were identified through *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* codes in inpatient and outpatient data sets.

From these data, we identified which LS MRI scans were considered inappropriate. LS MRIs were considered inappropriate in patients who did not have a red flag condition in the time frame of interest and those who did not receive appropriate conservative therapy.

We also investigated patient-, provider- and facility-level characteristics associated with inappropriate scans, as well as any regional differences in proportion of inappropriate scans. Patient-level characteristics included age, gender, and race. Provider-level variables included ordering provider type (attending physician, resident, physician’s assistant, and advanced practice nurse/nurse practitioner) and the clinic in which the scan was ordered (internal medicine/primary care, physical medicine and rehabilitation; neurology, neurosurgery, orthopedics, pain medicine, “other” medicine services, miscellaneous other medicine services, chiropractic care, and emergency department [ED] and urgent care). Other medicine services refer to various primary and specialty care clinics separate from the other categories of care (eg, geriatrics, oncology,

■ **Figure.** Determining the Appropriateness of a Lumbar Spine MRI



MRI indicates magnetic resonance imaging.  
 \*Both conditions and time frame must be met.  
 †Italics indicate modification to CMS/National Quality Forum Criteria.  
 All time frames refer to number of days prior to scan.

hospice, dementia clinic). Miscellaneous other services refer to all ancillary and support services (eg, cast clinic, social work, telephone triage). The facility-level variable included complexity, defined in 5 levels (1a, 1b, 1c, 2, and 3; from most to least complex).

Characteristics of inappropriate scans were evaluated using generalized estimating equations to account for clustering of patients within facilities. Our generalized estimating equations employed a logit link, a binomial distribution family, and an independent correlation structure. We ran sensitivity analyses in which we evaluated facility-level physical therapy penetration—defined as physical therapy visits per 1000 pro-rated patients—and in which, we evaluated alternative definitions of conservative therapy. Specifically, we required the conservative therapy visits to have an accompanying diagnosis of low back pain. Post estimation commands were used to compare outcomes among different levels of each categorical level; for example, to compare residents with each other provider type, physician’s assistants to each other provider type, etc. All analyses were conducted in SAS version 9.2 (SAS Institute, Inc, Cary, North Carolina).

## RESULTS

In FY 2012, 110,661 LS MRIs were ordered in the outpatient setting by 16,273 unique providers. Most patients received 1 LS MRI; only 3.7% of patients received more than 1. Each provider ordered a median of 3 LS MRIs and a mean of 6.8 LS MRIs. Of the 110,661 total scans, 33,998 (30.7%) were classified as inappropriate; these patients had no red flag conditions coded and did not receive conservative therapy in a VA facility prior to their scan (Table 1). The majority of scans classified as appropriate were done so because the patient was deemed to have received prior conservative therapy (65.3%). Another 16.6% of LS MRIs were classified as appropriate because the patient had a red flag condition. (Note that the numbers add up to more than 100% because patients could have had both a red flag condition and have received conservative therapy.)

Table 2 describes the demographics of the population, which on average, was male, white, and middle-aged. The greatest proportion of scans (42%) was ordered for patients seen at the most-complex (level 1a) facilities. However, the greatest proportion of inappropriate scans (36%) was or-

dered for patients seen at the least-complex facilities (level 3) (Table 2). The number of scans ordered varied greatly by clinic setting, with the greatest percentage of scans ordered by the primary care/internal medicine clinic (62%), and the fewest percentage ordered by neurosurgery and orthopedics (6% combined). The greatest percentage of total scans (69%) was ordered by medical doctors or doctors of osteopathy, and the lowest was ordered by physicians' assistants (8%). We did not find meaningful regional variation in proportion to scans considered inappropriate.

Results from generalized estimating equations revealed that patients aged under 35 years were more likely to have an inappropriate scan than those of all other ages ( $P < .0001$ ) (Table 3). Black patients were less likely to have an inappropriate scan compared with white patients (odds ratio [OR], 0.80;  $P < .0001$ ). Scans ordered at the lowest-complexity facility (level 3) were more likely to be inappropriate compared with those ordered at the highest-complexity facilities (OR, 1.27;  $P = .0096$ ). These multivariate results also show the ED or urgent care clinic to be the settings most strongly associated with an inappropriate scan (OR, 1.42;  $P < .0001$ , with reference category of primary care/internal medicine clinic). In fact, ED/urgent care providers were more likely than providers practicing in any other clinic to order inappropriate scans (Table 3). Primary care/internal medicine clinics were also associated with a high likelihood of ordering inappropriate scans; all other clinic settings were less likely to order inappropriate scans than the primary care/internal medicine clinic (Table 3). Neurology, neurosurgery, and orthopedic clinics all practiced similarly; after adjusting for covariates, each was equally likely to order an inappropriate scan compared with the others (Table 3). Medical doctors (MDs), doctors of osteopathy (DOs), nurses, and physician's assistants were also equally likely to order an inappropriate scan; however, residents were less likely to order an inappropriate LS MRI scan compared with MD/DOs (OR, 0.80;  $P < .0001$ ) (Table 3).

Results also show that 10.9% of providers ordered 50.1% of inappropriate scans, and 23.6% of providers ordered 74% of inappropriate scans (Table 4). There appeared to be a weak, volume-percent inappropriate relationship; that is, there was little evidence of a relationship between the volume of scans ordered by a provider and the percentage of those scans deemed inappropriate.

We ran sensitivity analyses in which we modified the categorization of E&M codes. CMS considers any E&M

■ **Table 1.** Appropriateness of Lumbar Spine MRI Scans<sup>a</sup>

Red Flag Condition	Conservative Therapy		Total
	No	Yes	
No	33,998 (30.7%)	58,340 (52.7%)	92,338 (8.3%)
Yes	4420 (4.0%)	13,903 (12.6%)	18,323 (16.6%)
Total	38,418 (34.7%)	72,243 (65.3%)	110,661

MRI indicates magnetic resonance imaging.

<sup>a</sup>Patients who received conservative therapy or who had a red flag condition were considered to have appropriate scans. Patients without a red flag condition or conservative therapy in the appropriate time frame were considered to have inappropriate scans.

visit between 28 and 60 days prior to the MRI to be conservative therapy, as long as the MRI was not ordered during that visit. Using this definition in our base-case, 63% of scans were conducted in patients who had a qualifying E&M visit. In sensitivity analyses, we restricted the E&M visit to have a diagnosis of LBP. Using this more restrictive definition, we found only 34% of LS MRI scans had a qualifying E&M visit, and thus, 53% of LS MRIs were considered inappropriate.

We also ran other sensitivity analyses. We tested a model with a covariate of facility-level physical therapy penetration. This variable was not a significant predictor of inappropriate LS MRI. Additionally, we ran a model on the subset of scans ordered by providers who ordered 5 or more scans per year, to avoid drawing conclusions based on a large number of providers each ordering few scans. Results did not change with respect to direction or significance. Third, we tested the inclusion of all prostate cancer in the red flag conditions, thus considering all LS MRI imaging in patients with a prostate cancer diagnosis in the previous 365 days to be appropriate. This resulted in slightly fewer (28.9%) LS MRIs being considered inappropriate.

We estimated the cost of providing each LS MRI in VA using the Decision Support System, the activity-based cost allocation system used by VA. We estimated that VA spent \$44.4 million on LS MRIs in FY 2012, including \$13.6 million on inappropriate scans.

## DISCUSSION

The extent of overuse of LS MRI has been the subject of much debate. Here, we find that, despite a strong body of evidence regarding the poor utility of LS MRI in nonchronic LBP, and the identification of LS MRI as a low-value service by multiple specialty societies,<sup>12-14</sup> 31% of LS MRIs conducted in VA in FY 2012 were inappropriate.

Estimates of inappropriateness of LBP imaging vary in the literature. The 2000 to 2006 claims-based analy-

**Table 2.** Characteristics of Lumbar Spine MRI Scans

Patient	Scans, n	Scans, %	Inappropriate Scans, n	Inappropriate Scans, %
Patient characteristics				
Age, years				
<35	11,789	10.7%	4490	38.1%
35-44	12,725	11.5%	4525	35.6%
45-54	22,511	20.3%	6907	30.7%
55-64	37,274	33.7%	10,691	28.7%
≥65	26,362	23.8%	7385	28.0%
Sex				
Male	99,462	89.9%	30,596	30.8%
Female	11,199	10.1%	3402	30.4%
Race				
White	70,373	70.2%	21,763	30.9%
Black	20,512	20.5%	5335	26.0%
Hispanic	7291	7.0%	2071	28.4%
Other	2075	2.0%	665	32.1%
Facility complexity				
1a (highest complexity)	46,806	42.3%	13,627	29.1%
1b	14,938	13.5%	4156	27.8%
1c	16,394	14.8%	4965	30.0%
2	21,071	19.0%	7124	33.8%
3 (lowest complexity)	11,452	10.3%	4126	36.0%
Clinic setting				
Emergency/urgent care	4318	3.9%	1753	40.6%
Physical medicine/rehabilitation	4751	4.3%	854	18.0%
Other medicine services	3815	3.4%	938	24.6%
Primary care/internal medicine	68,315	61.7%	23,162	33.9%
Neurology	4770	4.3%	995	20.9%
Neurosurgery	2212	2.0%	495	22.4%
Orthopedics	3757	3.4%	823	21.9%
Pain clinic	4013	3.6%	837	20.9%
Miscellaneous other services	2526	2.3%	466	18.4%
Unknown	12,184	11.0%	3675	30.2%
Provider type				
Doctor of medicine/doctor of osteopathic medicine	76,425	69.1%	24,001	31.4%
Allopathic/osteopathic resident	9504	8.6%	2125	22.4%
Physician's assistant	8470	7.7%	2632	31.1%
Advanced practice registered nurse/nurse practitioner	14,982	13.5%	4910	32.8%
Missing/other	1280	1.2%	330	25.8%
MRI indicates magnetic resonance imaging.				

sis of Pham and colleagues found that 29% of Medicare beneficiaries received x-ray, computed tomography (CT), or MRI inappropriately.<sup>18</sup> A 2004 to 2006 claims-based analysis of privately insured patients found 9% of patients

with LBP had an MRI within 14 days of initial diagnosis, and approximately 60% of patients had MRI, CT, or x-ray on the same day as the first diagnosis of LBP.<sup>19</sup> These variations in the ordering of imaging could be due to increas-

■ **Table 3.** Regression Results for Inappropriate Scans

Parameter	OR	Lower Bound CI	Upper Bound CI	P
Intercept	0.65	0.56	0.75	<.001
Age, years (ref = <35)				
35-44	0.91	0.87	0.96	.001
45-54	0.76	0.71	0.81	<.001
55-64	0.68	0.64	0.72	<.001
≥65	0.65	0.61	0.70	<.001
Race (ref = white)				
Black	0.82	0.76	0.89	<.001
Hispanic	0.90	0.79	1.02	.092
Other	1.04	0.94	1.15	.45
Unknown/missing	1.45	1.32	1.59	<.001
Sex (ref = male)				
Female	0.98	0.93	1.04	.55
Clinic setting (ref = primary care/internal medicine)				
Emergency/urgent care	1.42	1.28	1.58	<.001
Physical medicine/rehabilitation	0.46	0.33	0.63	<.001
Other medicine services	0.68	0.59	0.77	<.001
Neurology	0.57	0.51	0.64	<.001
Neurosurgery	0.64	0.55	0.74	<.001
Orthopedics	0.58	0.48	0.69	<.001
Pain clinic	0.54	0.47	0.61	<.001
Miscellaneous other services	0.43	0.36	0.52	<.001
Unknown	0.86	0.74	0.99	.038
Facility complexity (ref = 1a)				
1b	0.95	0.75	1.18	.62
1c	1.03	0.84	1.25	.81
2	1.18	0.98	1.42	.076
3 (lowest complexity)	1.27	1.06	1.52	.010
Provider type (ref = attending physician)				
Allopathic/osteopathic resident	0.80	0.74	0.87	<.001
Physician's assistant	0.99	0.90	1.07	.74
Advanced practice RN/nurse practitioner	1.06	0.99	1.14	.103
Other	1.11	0.82	1.49	.50

OR indicates odds ratio; ref, reference.

ing supply of MRI scanners from 2000 to 2012,<sup>20</sup> different ratios of acute and chronic LBP patients in study samples, and varying definitions of inappropriate.

We found inappropriate use of MRI in VA, even though its providers have little to no financial incentive to order more scans and have less malpractice liability than physicians in private practice—2 factors often cited as reasons for overuse of imaging.<sup>12,21</sup> This suggests that nonpecuniary factors play an important role in ordering behavior in VA. Thus, it also suggests that changes in financial incentives

alone will not be sufficient to reduce inappropriate ordering of LS MRI, and that provider and patient education may be necessary. Further research to explore the reasons for inappropriate ordering in this healthcare system, including the relative importance of lack of awareness of guidelines and concerns about patient satisfaction or reassurance<sup>17</sup> will be informative for quality improvement. Reducing inappropriate ordering of LS MRI also may be a question of educating patients, as well as providers. One randomized controlled trial found that patients receiving MRI were

**Table 4.** The Small Percentage of Providers Responsible for a Large Percentage of Inappropriate Scans

Scans Ordered by Provider, n	Scans in This Category, n	Providers Ordering This Number of Scans, n	Total Providers Ordering Scans, %	Total Inappropriate Scans, %	Total Scans, %	Inappropriate Scans, n	Inappropriate Scans Ordered by Provider, %
1	5751	5751	35.3%	4.0%	52.0%	1494	25.98%
2-3	8573	3639	22.4%	6.6%	7.7%	2263	24.60%
4-8	17,154	3052	18.7%	14.9%	15.5%	5081	29.60%
9-17	25,439	2064	12.7%	23.9%	23.0%	8131	32.00%
≥18	53,744	1768	10.9%	50.1%	48.5%	17,029	31.69%
Total	110,661	16,274	100%	100%	100%	33,998	30.72%

more satisfied than those receiving x-ray, independent of functional outcome.<sup>22</sup> This tactic may be increasingly important as organizations move to include patient satisfaction metrics in their measures of quality of care.

This is, to the best of our knowledge, the first analysis of NQF-endorsed CMS criteria to evaluate inappropriate ordering of LS MRI. Our analysis indicated that providers in primary care and internal medicine clinics, EDs, and urgent care clinics were most likely to order inappropriate LS MRIs. MDs, DOs, nurses, and physician’s assistants were equally likely to order inappropriately. Of note, we found that residents were significantly less likely than all other provider types to order inappropriately. Although resident behavior has been relatively understudied in the literature, Pitts and colleagues found that ED visits with residents were more likely to have resulted in advanced imaging orders compared with ED visits without residents.<sup>23</sup> Our dissimilar results may be due to questions of appropriateness; Pitts and colleagues did not evaluate the appropriateness of the imaging. We also found a weak relationship between the volume of scans ordered by a provider and the percentage of those scans considered inappropriate; high-ordering providers were not necessarily inappropriately ordering providers. Rather, we found that inappropriate LS MRIs were concentrated among relatively few providers. Approximately a quarter of providers (24%) ordered roughly three-fourths of all inappropriate scans (74%). Most providers (58%) ordered 3 or fewer scans per year, accounting for 60% of all LS MRIs ordered in this year. This suggests that the majority of providers do not need to be involved in interventions to reduce inappropriate use.

Our results indicate that interventions to reduce inappropriate ordering will be most appropriately directed at providers who order 18 or more scans per year, at providers and managers at the lowest-complexity facilities, and at providers in primary care/internal medicine clin-

ics. Interventions aimed at providers who order 18 or more scans per year represent an opportunity to have a substantive impact on reducing the absolute number of inappropriate MRIs ordered. Although ED and urgent care services have the greatest percentage of inappropriate scans (41% in univariate analysis), intervening in these clinics will have modest effects, as they account for only 4% of all scans. Primary care/internal medicine clinics accounted for 62% of all scans. Scans ordered in these settings were significantly more likely to be inappropriate, making them likely targets for intervention.

It is possible that scans are being ordered in these primary care/internal medicine clinics to meet the scheduling requirements of specialists; specialty clinics may require an LS MRI before seeing a patient. We found that orthopedics and neurosurgery, together, ordered only 6% of all LS MRIs in VA, suggesting this may be a factor. Further research is needed to determine if scans attributed to primary care/internal medicine providers were ordered to secure referral to specialty clinics; this research should inform any interventions to reduce inappropriate ordering.

Our sensitivity analyses showed that changes in the definition of evaluation and management—which are a major component of what constitutes conservative therapy—have a large influence on estimates of appropriateness. Using a more restrictive definition of evaluation and management reduced the number of scans with conservative therapy and almost halved the percentage of scans regarded as appropriate. We used the most generous definition of evaluation and management in our base-case analyses. Our choice of a generous definition was two-fold: We wished to be consistent with the definition developed by CMS, and we prioritized identifying sensitivity (true appropriateness) over specificity (true inappropriateness). Maximizing sensitivity represents a cautious approach that avoids erroneously categorizing scans as inappropriate.

Use of imaging that provides no benefit to patients, and may in fact cause harm through catalyzing medical interventions for common and asymptomatic abnormalities, represents waste within the healthcare system. With healthcare expenditures of \$2.6 trillion in 2010 and a consistently positive rate of growth in healthcare costs,<sup>24</sup> waste is something the US healthcare system and US economy can ill afford. Our analysis indicates an excess annual cost of \$13.7 million for LS MRI in VA. Outside of VA, it has been estimated that if all US adults were treated in accordance with imaging guidelines for LBP, the healthcare system would save at least \$300 million annually (in 2009 dollars),<sup>25</sup> with even greater cost savings achieved if accounting for costs associated with treating asymptomatic disease.

### Limitations

This study was a retrospective analysis of administrative VA data and is subject to certain limitations. We used administrative data to assess the appropriateness of LS MRI. Administrative data do not contain the complete details of the content of care; there may be data captured through history and physical (eg, regarding duration of treatment) that was not assigned an ICD-9-CM code. For example, it is possible that patients received some conservative therapy in a non-VA setting prior to their VA MRI, or that physicians had some rationale for ordering the MRI that was not captured in the coding of care such as progressively worsening symptoms; in this case, our analysis would overestimate the proportion of scans that were inappropriate. However, we employed CMS-generated and NQF-endorsed administrative data-based algorithms that were generous in their categorization of appropriate scans in order to mitigate the likelihood of this. Additionally, MRIs conducted at VA do not contain diagnosis codes; our analysis thus evaluated all LS MRIs. It is possible that we included LS MRIs that were conducted for reasons other than low back pain. This may overestimate the proportion of LS MRIs considered inappropriate. However, the appropriateness of LS MRIs is a function of both the reason for the LS MRI (eg, low back pain), as well as the reasons for which the LS MRI may be warranted (ie, prior failed conservative therapy or a patient with a red flag condition). As we used the least restrictive definition of conservative therapy (that which did not require the conservative therapy visit to have a diagnosis of low back pain) to evaluate care prior to the scan within VA, it is more likely that our analysis actually underestimates the proportion of scans that were inappropriate.

VA is a unique healthcare setting; our results may differ from those of studies of other US providers. While

our analysis has limited generalizability outside of VA, analyzing this population provides important insight, by illuminating that even in a healthcare system largely absent of financial and other incentives for overuse, inappropriate ordering of LS MRI is still a substantial problem. Furthermore, our results may be of particular interest to accountable care organizations, whose financial incentives and organizational structure more closely resemble those of VA.

## CONCLUSIONS

Despite recommendations from specialty societies that LS imaging should be performed only in patients who have severe or progressive neurological deficits or signs and symptoms of serious underlying conditions, we found that 31% of LS MRIs performed in a US healthcare system largely absent financial incentives for overuse—were inappropriate. This work reveals 2 important insights that will be informative for quality improvement purposes. First, our work suggests that nonpecuniary factors have a role to play in inappropriate ordering of imaging for low back pain; efforts to reduce inappropriate ordering cannot rely on financial incentives alone. Second, we found a high concentration of inappropriate ordering among few providers, indicating that provider-focused efforts to reduce inappropriate orders should be targeted rather than universal. Further work should be conducted to assess the proportion of inappropriate LS MRI in environments where defensive medicine or fee-for-service incentives may be at play.

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