

## HEALTH SERVICES RESEARCH

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## The Cascade of Medical Services and Associated Longitudinal Costs Due to Nonadherent Magnetic Resonance Imaging for Low Back Pain

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Manuel Cifuentes, MD, MPH, ScD\*‡ and Glenn Pransky, MD, MOcCH\***Study Design.** Retrospective cohort study.**Objective.** To compare type, timing, and longitudinal medical costs incurred after adherent *versus* nonadherent magnetic resonance imaging (MRI) for work-related low back pain.**Summary of Background Data.** Guidelines advise against MRI for acute uncomplicated low back pain, but is an option for persistent radicular pain after a trial of conservative care. Yet, MRI has become frequent and often nonadherent. Few studies have documented the nature and impact of medical services (including type and timing) initiated by nonadherent MRI.**Methods.** A longitudinal, workers' compensation administrative data source was accessed to select low back pain claims filed between January 1, 2006 and December 31, 2006. Cases were grouped by MRI timing (early, timely, no MRI) and subgrouped by severity ("less severe," "more severe") (final cohort = 3022). Health care utilization for each subgroup was evaluated at 3, 6, 9, and 12 months post-MRI. Multivariate logistic regression models examined risk of receiving subsequent diagnostic studies and/or treatments, adjusting for pain indicators and demographic covariates.**Results.** The adjusted relative risks for MRI group cases to receive electromyography, nerve conduction testing, advanced imaging, injections, and surgery within 6 months post-MRI risks in the range

from 6.5 (95% CI: 2.20–19.09) to 54.9 (95% CI: 22.12–136.21) times the rate for the referent group (no MRI less severe). The timely and early MRI less severe subgroups had similar adjusted relative risks to receive most services. The early MRI more severe subgroup cases had generally higher adjusted relative risks than timely MRI more severe subgroup cases. Medical costs for both early MRI subgroups were highest and increased the most over time.

**Conclusion.** The impact of nonadherent MRI includes a wide variety of expensive and potentially unnecessary services, and occurs relatively soon post-MRI. Study results provide evidence to promote provider and patient conversations to help patients choose care that is based on evidence, free from harm, less costly, and truly necessary.**Key words:** low back pain, radiculopathy, nonspecific back pain, evidence-based guidelines, MRI, workers' compensation, costs.**Level of Evidence:** N/A**Spine 2014;39:1433–1440**

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A cascade effect in medical care refers to “a chain of events initiated by an unnecessary test...which results in ill-advised tests or treatments that may cause avoidable adverse effects and/or morbidity”<sup>1</sup> and is well documented across several specialties of medical care. Electronic fetal monitoring has been associated with a 40% higher Cesarean section rate, without fetal outcome improvement.<sup>2</sup> Unnecessary cardiac stress tests generating false-positive results lead to significant morbidity and mortality due to unnecessary invasive testing and surgery.<sup>3</sup>

Radiological lumbar imaging is also problematic as it frequently reveals “abnormalities” of uncertain clinical significance similar to those seen in asymptomatic individuals.<sup>4</sup> Magnetic resonance imaging (MRI) has become more frequent as it has no radiation exposure risk,<sup>5,6</sup> and is problematic because it is highly sensitive but often not specific in identifying the cause of back pain.<sup>7-9</sup>

Evidence-based acute low back pain (LBP) guidelines recommend against routine MRI, except for “red flag” conditions (severe trauma, infection, cancer, cauda equina syndrome). MRI is an option to guide epidural steroid injections or surgery for persistent radicular pain after a trial of conservative care.<sup>10,11</sup>

Guideline recommendations are intended to avoid subsequent unnecessary and iatrogenic care, yet there is little information to document the extent and timing of unnecessary or nonindicated medical services after nonadherent MRI. Services received post-MRI have been documented in a few studies, but none have assessed their type and timing.<sup>12-18</sup>

The study purpose was to compare the nature, timing, and associated longitudinal costs of post-MRI medical services in persons receiving early MRI with those who never had MRI or had MRI after a trial of conservative care, using a health services data set. It was hypothesized that rates and costs of post-MRI diagnostic and/or invasive services would be higher in patients who had early MRI than for those who never had MRI or who had MRI after a trial of conservative care, after grouping by severity and controlling for pain indicators and demographic factors.

## MATERIALS AND METHODS

### Subjects

As previously described,<sup>12</sup> all accepted LBP claims filed between January 1, 2006 and December 31, 2006 were extracted from a nationally representative United States workers' compensation (WC) administrative data source (representing approximately 10% of the private WC market). Data extracted for a 2-year period from the date of LBP onset, included age, sex, job tenure, paid medical bills, and associated *Clinical Procedural Terminology* codes,<sup>19</sup> and *International Classification of Diseases, Ninth Revision* diagnostic codes assigned to services provided within 15 days postonset.<sup>20</sup> Inclusion criteria included at least 1 day compensated lost time and at least 1 year of job tenure. Complex cases (those with red-flag conditions, non-LBP diagnoses, or multiple injuries) and cases with a LBP claim within the prior year were excluded, yielding a cohort of 3253. The study was approved by the Institutional Review Board of the Liberty Mutual Research Institute for Safety.

### Exposure

To compare services received after the initial lumbar MRI (based on *Clinical Procedural Terminology* codes 72148, 72149, and 72158) with those without MRI, 3 groups were specified according to the timing of the MRI.<sup>19</sup> "No MRI" cases received no MRI during the 2-year study period. "Early MRI" cases received MRI within the first 30 days.<sup>12</sup> Because various guidelines recommend different timeframes (from 4 wk<sup>21</sup> to 6 wk<sup>22</sup>) before obtaining MRI to evaluate patients with persistent radicular back pain or spinal stenosis, "timely MRI" group was defined as those who received MRI starting at 42 days postonset through 180 days (to exclude the few cases whose imaging was delayed for either complicating medical or nonmedical reasons). On the basis of these definitions, 231 cases were excluded for MRI that fell outside of the specified periods (170 from 31 to 41 d postonset, 61 after 180 d postonset), resulting in a final cohort of 3022 from 48 states.

Within each group, cases were classified into "more severe" and "less severe" subgroups based on *International*

*Classification of Diseases, Ninth Revision* codes, to evaluate whether severity affected utilization. The more severe subgroup included those who received any services with diagnoses including herniated disc, lumbar radiculopathy or neuropathy, spinal stenosis, sciatica, or possible instability. Remaining cases assigned to the less severe subgroup had diagnostic codes associated with degenerative changes, non-specific back pain, or miscellaneous diagnoses (Supplemental Digital Content, Table 1 available at <http://links.lww.com/BRS/A872>).

### Outcomes and Follow-up

For each subgroup, the occurrence of services received post-MRI was identified using *Clinical Procedural Terminology* codes and based on the first receipt of diagnostic studies (electromyography, nerve conduction velocity, and advanced imaging) and/or invasive treatments (injections and surgery) (Supplemental Digital Content, Table 2 available at <http://links.lww.com/BRS/A872>). Advanced imaging included myelography, discography, computed tomography, bone scan, and repeat MRI. Injections included epidural, facet and sacroiliac joint, and trigger point injections. Surgery included lumbar discectomy, laminectomy, and fusions.

Health care utilization for each MRI subgroup was evaluated at 3, 6, 9, and 12 months post-MRI. A comparable post-MRI follow-up period for the no MRI group was defined as starting at 15 days (median days to MRI for early MRI group) postonset.

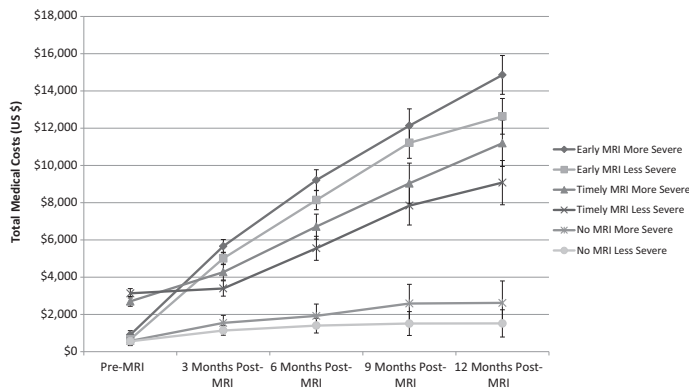
Total medical costs, based on paid medical bills, were computed for each subgroup. Costs for the pre-MRI periods were aggregated from date of onset to the first 14 days for the no MRI groups, up to 30 days postonset for the early MRI groups, and between 42 and 180 days for the timely MRI groups. Post-MRI costs were aggregated from the day after MRI (or the 16th day for the no MRI groups) to the 3-, 6-, 9-, and 12-month follow-up dates. All totals exclude MRI costs.

### Covariates

Because higher opioid usage has been shown to be associated with higher medical costs and an increased risk to undergo subsequent surgery,<sup>23</sup> we adjusted for individual differences in pain indicators. Early opioid use (receipt of opioid analgesics within 15 days postonset) and the associated total morphine-equivalent amount (MEA) were used as surrogates for pain. Morphine-equivalent amount was calculated on the basis of the number of pills, strength, and equianalgesic dose.<sup>23</sup> Demographic covariates included age, sex, and job tenure.

### Statistical Analysis

To examine services received post-MRI and compare outcomes of the early and timely MRI groups to the no MRI groups for comparable periods, the percentage of cases within each MRI subgroup who received each category of services at 3-month intervals up to a year post-MRI was first examined. Next, multivariate log binomial regression was used to model the relative risk (risk ratio) of receiving a category of service for each MRI subgroup. Repeated measures analysis



**Figure 1.** Total medical costs over time by MRI diagnostic group. MRI indicates magnetic resonance imaging.

of variance was used to compare medical expenditures across time for each MRI group (Figure 1). Analysis of variances and pairwise comparisons were used to compare the MRI groups on their demographic and pain characteristics. All models adjusted for these potential covariates. SAS software, version 9.2 (SAS Institute Inc., Cary, NC) was used for all analyses.

**RESULTS**

Table 1 presents descriptive statistics on the demographic and pain covariates for each MRI subgroup. More than 80% of the more severe subgroups had an early diagnosis of radiculopathy (data not shown). All MRI groups had higher percentages of those who received early opioids. Both early MRI groups had the highest MEA levels in the first 15 days. The timely MRI less severe subgroup received MRI significantly sooner than the timely MRI more severe subgroup (by an average of 11 d).

The majority of services were received relatively soon post-MRI. Most of those who received injections, nerve testing, or surgery, and about half who received advanced imaging by the 6-month period received these services within the first 3 months post-MRI (Table 2). Therefore, we focused on modeling the risk ratios for services at 6 months post-MRI. Model results for outcomes at 3, 9, and 12 months post-MRI were similar (data not shown).

Risk ratios to receive diagnostic services and invasive treatments at 6 months post-MRI were highest for the early MRI groups, ranging between 17.8 and 54.9 times as likely as the referent group (no MRI less severe), after adjusting for demographic and pain covariates (Table 3). Adjusted relative risks for the timely MRI subgroups were similarly high, ranging between 6.5 and 42.8 times as likely as the referent group. Comparisons of the MRI subgroups (within severity levels) showed that the risk ratios for receiving these services for the early and timely MRI groups were significantly higher than for the no MRI group. Relative risks for receipt of surgery and injections at 6 months post-MRI for the early MRI subgroups were higher than the timely MRI subgroups (Table 4). There was moderate variation in the risk ratios to receive services due to severity within MRI groups (Supplemental Digital Content, Table 3 available at <http://links.lww.com/BRS/A872>).

Medical costs (excluding MRI costs) for the early MRI groups were highest and increased the most over time. Costs for the timely MRI groups were second highest, whereas the no MRI groups had a much lower rate of cost increase over time (Figure 1).

**DISCUSSION**

In this longitudinal study, lumbar MRI without indication led to a subsequent cascade of diagnostic and therapeutic services

**TABLE 1. Descriptive Statistics for Demographics and Covariates**

MRI Groups by Severity	Demographics		Covariates			
	Age, yr	Sex, Female %	Tenure, yr	Early Opioid, %	MEA in First 15 d,* mg	Time to First Lumbar MRI, d
No MRI less severe (n = 1546)	40.7 (40.1–41.3)	31.0	6.8 (6.5–7.2)	22.5	316.6 (274.8–358.3)	...
No MRI more severe (n = 271)	41.9 (40.6–43.1)	33.9	7.8 (6.8–8.8)	21.8	416.8 (253.1–580.6)	...
Timely MRI less severe (n = 214)	39.9 (38.5–41.3)	34.1	6.7 (5.7–7.6)	38.8	352.0 (289.7–414.3)	69.7 (66.0–73.5)
Timely MRI more severe (n = 209)	42.8 (41.4–44.2)	38.3	7.7 (6.5–8.8)	28.2	377.5 (276.5–478.4)	81.0 (76.0–86.1)
Early MRI less severe (n = 458)	42.1 (41.2–43.0)	24.7	7.9 (7.2–8.6)	34.1	523.5 (407.9–639.2)	14.8 (14.0–15.6)
Early MRI more severe (n = 324)	42.4 (41.4–43.5)	22.2	7.9 (7.1–8.8)	42.0	529.2 (436.0–622.4)	16.3 (15.5–17.2)

Data represent means with 95% confidence intervals in parentheses.  
 \*Means for MEA (morphine-equivalent amount) in first 15 days are calculated only for those with opioid prescriptions.  
 MRI indicates magnetic resonance imaging.

**TABLE 2. Descriptive Outcomes Post-MRI**

MRI Groups by Severity	Injection		EMG/NCV		Advanced Imaging		Surgery	
	3 mo, %	6 mo, %	3 mo, %	6 mo, %	3 mo, %	6 mo, %	3 mo, %	6 mo, %
No MRI less severe (n = 1546)	1.0	1.4	0.1	0.3	0.6	0.8	0.2	0.5
No MRI more severe (n = 271)	2.6	3.7	1.5	1.5	0.4	0.4	0.7	0.7
Timely MRI less severe (n = 214)	25.2	35.5	6.1	11.2	7.0	13.1	0.9	2.8
Timely MRI more severe (n = 209)	27.8	36.8	9.6	13.9	5.3	10.0	5.3	8.6
Early MRI less severe (n = 458)	33.0	38.9	8.1	12.2	7.6	14.4	8.1	13.3
Early MRI more severe (n = 324)	36.7	46.6	13.9	17.6	8.6	17.0	10.2	16.0

Percentages represent the frequency of the first receipt of these outcomes post-MRI within each MRI diagnostic group. Injections include injections of the epidural space, facet and sacroiliac joints, and trigger points. Advanced imaging includes myelography, discography, CT scans, bone scans, and repeat MRIs. Surgery includes lumbar discectomy, laminectomy, and fusions.  
MRI indicates magnetic resonance imaging; CT, computed tomography; EMG/NCV, electromyography/nerve conduction velocity.

(including surgery), which generally occurred soon after MRI. This cascade was more related to MRI than to severity or pain indicators, suggesting an effect of guideline nonadherence. Even after grouping by severity and controlling for pain and demographic covariates, early MRI was significantly associated with a large and sustained medical cost escalation, reflecting an overall medical utilization increase, which was greater than seen for the no MRI and timely groups.

This study is the first to assess post-MRI services after a trial of conservative care (timely MRI) and to assess the financial impact of services after guideline-adherent conservative care, including the timing, type of services, and costs over time, after grouping by severity and controlling for covariates. This study also provides more detail than other studies regarding services received post-MRI.<sup>12,14-18</sup> A recent study of WC claimants in Washington State found a similar increased likelihood to receive injections and surgery and incur higher medical costs after nonadherent early MRI, but did not assess services or costs incurred after timely MRI.<sup>18</sup> The associated increased surgery risk for both the early and timely less severe subgroups supports similar findings in primary care and Medicare populations.<sup>14,15</sup> Early MRI has also been associated with prolonged disability, even after controlling for potential confounders.<sup>12,17</sup> Another study found little change in services associated with early MRI, but patients' sense of well-being decreased after receiving imaging results.<sup>24</sup>

The findings are troublesome because cases were selected on the basis of the absence of red-flag indications that might warrant early MRI. Although MRI may be considered for persistent radicular pain after a course of conservative care to guide epidural steroid injection or surgery for radiculopathy,<sup>11</sup> the timely MRI less severe subgroup was unlikely to have radiculopathy and was unlikely to have indications for many

of the subsequent services. However, their receipt of services was similar to the timely more severe subgroup, suggesting unnecessary and costly care.

It is striking that the cascade of services received by the early MRI less severe subgroup was similar to the other 3 MRI subgroups. In addition, this subgroup underwent surgery significantly sooner than the timely more severe subgroup. The finding that the early and timely less severe subgroups received MRI sooner than the 2 more severe subgroups suggests that the MRI and surgery were done for inappropriate reasons.

The data do not indicate how MRI testing led to the cascade, however, several pathways can be postulated. Patients concerned about nonspecific symptoms may pressure providers to order MRI to find a physical cause of their pain, and then demand interventions to address the purported cause. Providers may think that they are obligated to address abnormalities found prior to returning patients to work, or employers may mistakenly think MRI demonstrates whether the employee is "safe" to return to work.

Other possibilities include a desire by physicians to identify a treatable physical cause, or economic and social factors. Focusing treatment on potentially unrelated diagnostic findings reflects the biomedical back pain model that predominates for many patients<sup>25</sup> and providers,<sup>26</sup> and seems to drive treatment.<sup>27</sup> An invasive pain treatment model has been advocated, directing therapeutic interventions at multiple "pain generators," based on an overinterpretation of the meaning of "abnormalities"<sup>28</sup> that are commonly observed in asymptomatic people.<sup>7-9</sup> As a result, patients may become engaged in an unhelpful treatment model that starts with MRI, followed by injections and additional diagnostic testing. However, a systematic review found little value in subsequent interventions based solely on such abnormalities<sup>10</sup> and a recent report



**TABLE 3. Adjusted Multivariate Log Binomial Model Results at 6 Months Post-MRI**

MRI Groups by Severity	Injections			EMG/NCV			Advanced Imaging			Surgery		
	RR	Wald 95% CI	P	RR	Wald 95% CI	P	RR	Wald 95% CI	P	RR	Wald 95% CI	P
No MRI more severe (n = 271)	2.70	1.29–5.67	0.009	4.59	1.24–16.98	0.023	0.48	0.06–3.66	0.48	1.64	0.34–7.83	0.54
Timely MRI less severe (n = 214)	25.17	15.86–39.95	0.001	35.13	13.53–91.22	0.001	16.60	8.56–32.18	0.001	6.48	2.20–19.09	0.001
Timely MRI more severe (n = 209)	26.24	16.56–41.58	0.001	42.77	16.73–109.36	0.001	13.04	6.51–26.11	0.001	20.07	8.49–47.46	0.001
Early MRI less severe (n = 458)	27.40	17.64–42.57	0.001	38.08	15.33–94.59	0.001	17.81	9.70–32.71	0.001	28.35	13.05–61.58	0.001
Early MRI more severe (n = 324)	32.70	21.03–50.84	0.001	54.89	22.12–136.21	0.001	20.53	11.08–38.01	0.001	33.80	15.46–73.87	0.001
No MRI less severe (n = 1546)	Ref.			Ref.			Ref.			Ref.		

Ref = no MRI less severe. Estimates of risk ratios (relative risk) adjusted for age, sex, job tenure, and use of early opioids.  
MRI indicates magnetic resonance imaging; EMG/NCV, electromyography/nerve conduction velocity; RR, relative risk; 95% CI, 95% confidence interval; Ref, Reference group.

**TABLE 4. Comparisons Across MRI Groups (Within Severity) at 6 Months Post-MRI**

	Injections			EMG/NCV			Advanced Imaging			Surgery		
	RR	Wald 95% CI	P	RR	Wald 95% CI	P	RR	Wald 95% CI	P	RR	Wald 95% CI	P
Less severe												
Early MRI vs. no MRI (ref.)	27.40	17.64–42.57	0.001	38.08	15.33–94.58	0.001	17.81	9.70–32.71	0.001	28.35	13.05–61.58	0.001
Timely MRI vs. no MRI (ref.)	25.17	15.86–39.95	0.001	35.13	13.53–91.22	0.001	16.60	8.56–32.18	0.001	6.48	2.20–19.09	0.001
Early MRI vs. timely MRI (ref.)	1.09	0.88–1.35	0.43	1.08	0.69–1.70	0.73	1.07	0.71–1.62	0.74	4.38	1.92–9.96	0.001
More severe												
Early MRI vs. no MRI (ref.)	12.10	6.51–22.49	0.001	11.97	4.93–32.63	0.001	42.99	5.98–308.95	0.001	20.67	5.08–84.14	0.001
Timely MRI vs. no MRI (ref.)	9.71	5.16–18.30	0.001	9.32	3.33–26.11	0.001	27.31	3.70–201.33	0.001	12.28	2.88–52.26	0.001
Early MRI vs. timely MRI (ref.)	1.25	1.01–1.54	0.04	1.28	0.85–1.95	0.24	1.57	0.98–2.53	0.06	1.68	1.01–2.80	0.04

Multivariate log binomial model results comparing across MRI groups within severity. Estimates of risk ratios (relative risk) adjusted for age, sex, job tenure, and use of early opioids.  
MRI indicates magnetic resonance imaging; EMG/NCV, electromyography/nerve conduction velocity; ref., reference group; RR, relative risk; 95% CI, 95% confidence interval.

indicated that there is insufficient evidence to support injections for chronic back pain management.<sup>29</sup> Although a large percentage of the early MRI more severe subgroup had a radiculopathy-related diagnosis for which guidelines clearly recommend a “wait and see” approach, many providers are influenced by this diagnosis and obtain imaging prematurely.<sup>30</sup> Such an approach can lead to heightened urgency for both providers and patients to focus on “fixing” a physical abnormality that, in many cases, resolves spontaneously within a month.<sup>31</sup> Such a focus diverts patients from more appropriate noninvasive interventions that can lead to better long-term functional results.

Economic and social factors may also be important drivers of nonadherent imaging, including physician self-referral, other overutilization financial incentives, oversupply of MRI scanners, and entitlement viewpoints that have all been documented to influence the rate of LBP health care utilization.<sup>13,32,33</sup> Studies have reported excessive MRI utilization related to self-referral by physician-owners or shareholders of imaging centers.<sup>34–36</sup> Swedlow *et al*<sup>34</sup> concluded that self-referral increased WC medical costs by increasing the frequency of requests for clinically inappropriate MRIs. Baras and Baker<sup>13</sup> reported that increases in surgery for nonspecific LBP and in early MRI were associated with an increase in the supply of scanners.

Although this study did not access MRI results, 2 studies reported that findings from nonadherent MRIs were more likely to be negative.<sup>37,38</sup> Similarly, whether the timely MRI more severe group patients had appropriate indications for MRI cannot be determined with certainty; it is much more likely that they met some of the indications, compared with those who received early MRI. They were more likely to represent cases with radiculopathy that failed to resolve over time and it is suggested that their medical cost trajectory in the first-year post-MRI reflects what would be expected for guideline-adherent care.

Study strengths include robust longitudinal data, with almost complete capture of detailed information on each paid LBP-related medical service regardless of provider because WC is legally the first payer for all injury-related services for the treatment duration. The data represent a working age population that is not represented in the majority of national LBP health services research studies in the United States, which often rely on Medicare data. The cohort’s national scope presents a snapshot of typical community-based practice in 48 states.

There are several potential limitations. The first is that WC insurance is a unique system and medical utilization tends to be higher than in general medical care.<sup>39,40</sup> Yet, these results seem to parallel utilization trends in Medicare data and in a smaller community-based study.<sup>27</sup> Administrative data has known limitations including absence of clinical information to classify cases into more or less severe categories or history of recurrent or chronic LBP.<sup>41,42</sup> However, results from a prior study based entirely on administrative data<sup>12</sup> were similar to a subsequent study based on clinical information extracted from claims medical reports,<sup>17</sup> suggesting that administrative

data can be used to both select acute LBP cases and *International Classification of Diseases, Ninth Revision* codes can be used to classify cases into severity categories. Although other potential covariates including socioeconomic level or race are not available, they are not indicators for MRI utilization. Finally, administrative data lack information on the decision-making process that leads to obtaining MRI and subsequent medical services.

## CONCLUSION

The impact of nonadherent MRI utilization is significant in terms of the cost of potentially unnecessary and unhelpful medical services, which occurs relatively soon after MRI. The additional burden of a lost sense of well-being and of having a mistaken conceptual causal model and solution for one’s LBP is difficult to estimate. The study results provide evidence to promote conversations between providers and patients to help patients choose care that is supported by evidence, free from harm, and truly necessary.

Further research is needed to identify specific pathways and decisions that lead to obtaining nonadherent MRI and a subsequent cascade of services. Longitudinal interviews could provide information on the important cascade-enhancing factors suggested by Deyo,<sup>1</sup> including patient demands, over-interpretation, intolerance of ambiguity, economic incentives, and referral patterns that lead to overutilization, and unreasonable promises of a “cure.”

## ➤ Key Points

- ❑ MRI without clear indications led to a cascade of subsequent diagnostic and therapeutic services (including surgery), which generally occurred within 6 months after imaging.
- ❑ This cascade was more related to the MRI than to severity, pain indicators, or demographic characteristics.
- ❑ Even after grouping by severity and controlling for pain indicators and demographic factors, early MRI (receipt <30 d postonset) was significantly associated with a large and sustained escalation in medical costs, reflecting increases in overall medical utilization, which was greater than the costs for the no MRI and timely (receipt >42 d postonset) groups.
- ❑ Study results provide evidence to promote provider and patient conversations to help patients choose care that is based on evidence, free from harm, less costly, and truly necessary.

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