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Impact of IT-Enabled Intervention on MRI Use for Back Pain

Ivan K. Ip, MD, MPH^{1,2,3,5}, Esteban F. Gershanik, MD, MPH, MMSc^{1,2,3,5}, Louise I. Schneider, MD^{1,2,3,5}, Ali S. Raja, MD, MPH, MBA^{1,2,4,5}, Wenhong Mar, MSc^{1,2}, Steven Seltzer, MD^{2,5}, Michael J. Healey, MD^{3,5,6}, and Ramin Khorasani, MD, MPH^{1,2,5}

¹Center for Evidence-Based Imaging, Organization Harvard Medical School Boston, Massachusetts

²Departments of Radiology, Organization Harvard Medical School Boston, Massachusetts

³Medicine, Organization Harvard Medical School Boston, Massachusetts

⁴Emergency Medicine, Organization Harvard Medical School Boston, Massachusetts

⁵Brigham and Women's Hospital, Organization Harvard Medical School Boston, Massachusetts

⁶Brigham and Women's Physician, Organization Harvard Medical School Boston, Massachusetts

Abstract

Background—Examine the impact of a multi-faceted, clinical decision support (CDS)-enabled intervention on magnetic resonance imaging (MRI) use in adult primary care patients with low back pain.

Methods—After a baseline observation period, we implemented a CDS targeting lumbar-spine MRI use in primary care patients with low back pain through our computerized physician order entry (CPOE) as well as two accountability tools: 1) mandatory peer-to-peer consultation when test utility was uncertain and 2) quarterly practice pattern variation reports to providers. Our primary outcome measure was rate of lumbar-spine MRI use. Secondary measures included utilization of MRI of any body part, comparing to that of a concurrent national comparison, as well as proportion of lumbar-spine MRI performed in the study cohort that was adherent to

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Corresponding author: Ivan K. Ip, MD, MPH Center for Evidence-Based Imaging Department of Radiology and Medicine Brigham and Women's Hospital 20 Kent Street, 2nd floor, Boston, MA 02120 iip@partners.org.

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evidence-based guideline. Chi-square, t-tests, and logistic regression were used to assess pre- and post-intervention differences.

Results—In the study cohort, pre-intervention, 5.3% of low back pain-related primary care visits resulted in lumbar-spine MRI compared to 3.7% of visits post-intervention ($p < 0.0001$, Adjusted Odds Ratio 0.68). There was a 30.8% relative decrease (6.5% vs. 4.5%, $p < 0.0001$, Adjusted Odds Ratio 0.67) in the use of MRI of any body part by the primary care providers in the study cohort. This difference was not detected in the control cohort (5.6% vs. 5.3%, $p = 0.712$). In the study cohort, adherence to evidence-based guideline in the use of lumbar-spine MRI increased from 78% to 96% ($p = 0.0002$).

Conclusions—CDS and associated accountability tools may reduce potentially inappropriate imaging in patients with low back pain.

Keywords

imaging use; health information technology; clinical decision support

Introduction

With the substantial financial investment associated with the Health Information Technology for Economic and Clinical Health (HITECH) provisions of the American Recovery and Reinvestment Act of 2009 comes great expectations that health information technology (HIT) will not only enhance patient safety and improve quality of care, but also reduce waste such as unnecessary high-cost medical imaging. Yet, the impact of HIT on healthcare delivery remains largely unclear. Kellermann noted that we have yet to fully capitalize on the \$81 billion in annual cost savings that was originally projected¹. In fact, McCormick et al reported that HIT may even be associated with an unintended consequence of increasing cost².

Low back pain (LBP) is very common³ affecting approximately 70-85% of Americans over their lifetimes⁴ and one quarter of U.S. adults report LBP within the previous 3 months⁵. The estimated direct healthcare costs associated with spine problems exceeded \$85 billion, representing 9% of national health expenditures⁶. While lumbar spine magnetic resonance imaging (LS-MRI) is the preferred diagnostic examination for most spinal diseases (e.g., cauda equina syndrome, infection, or neoplasm), its value in the investigation of simple back pain may be limited⁷, as imaging abnormalities and clinical symptoms are poorly correlated⁸ and routine imaging is not associated with better pain relief, higher functioning, or improved quality of life⁹⁻¹². Based on an extensive systematic review, the joint guidelines of the American College of Physicians and the American Pain Society (ACP/APS) recommend against routine imaging in patients with nonspecific LBP (i.e., no severe or progressive neurologic deficits or evidence of serious underlying conditions)¹³. Qaseem et al. identified imaging in patients with nonspecific LBP to be one clinical situation that does not reflect high-value care¹⁴.

Despite evidence that routine imaging does not improve patient outcomes, clinical practice is often inconsistent with the ACP/APS guidelines and the use of LS-MRI has continued to

increase, and with wide practice variation^{15,16}. Mafi et al¹⁷ recently found that the management of back pain has relied increasingly on guideline discordant care, with more frequent use of narcotics and high-cost imaging since 1999. The purpose of this study was to examine the impact of a multi-faceted, clinical decision support (CDS)-enabled intervention based on the published ACP/APS guidelines,¹⁸ on the use of MRI in adult primary care patients with low back pain.

Materials and Methods

Study setting and cohort

Our study site consists of an integrated health system, centered around an urban academic quaternary care hospital, with an outpatient network that spans 183 practices and 1,200 physicians. The requirement to obtain informed consent was waived by the system's Institutional Review Board for this HIPAA-compliant study. The study cohort included all adult patients who presented with LBP to a primary care physician (PCP) affiliated with our institution between 2007 and 2010. To identify primary care visits for LBP-related conditions, we queried our institutional billing database to identify all primary care encounters of patients aged 18 or older with an associated primary or top 2 secondary diagnosis of LBP using International Classification of Diseases 9th Revision (ICD-9) codes (Appendix Table 1)^{17,19}.

Control cohort

To account for secular differences in MRI utilization, we selected a control cohort consisting of primary care visits of patients with LBP captured from the publicly available National Ambulatory Medical Care Survey (NAMCS) during the same time period. The NAMCS survey was designed to be representative of outpatient care in the United States, with data collected using a standardized form completed during each patient visit. NAMCS included data on patient's demographics, medications listed, laboratory and imaging studies ordered during the visit, as well as up to 3 diagnoses derived from ICD-9 codes. NAMCS does not provide details of the specific body part imaged with MRI, hence the need to compare MRI of any body part utilization. Using surveys conducted between 2007 and 2010, we included only primary care visits in adult patients aged 18 or older. We used ICD-9 diagnosis (primary or secondary) to identify back pain-related visits based on the same codes as for the study cohort.

Intervention

After a baseline data-gathering observational period of 7 quarters, we implemented a multi-faceted intervention to promote guideline adherence in the use of LS-MRI in patients with LBP-related primary care visits in the study cohort. Our institution's computerized physician order entry (CPOE) system for imaging (Percipio, Medicalis Corp, San Francisco, CA) is integrated into our health information technology infrastructure²⁰. Based on the clinical history input via the CPOE system, real-time CDS launches, advising the orderer regarding the best diagnostic strategy if evidence is available. The CDS content for LS-MRI is derived from the ACP/APS guidelines¹³, which are based on systematic review and supported by moderate quality evidence. In the absence of any clinical “red flags” (for which LS-MRI

would be considered appropriate), CDS suggests the LS-MRI is not indicated (Figure 1). The clinician may cancel the request, or ignore the CDS and proceed with the order. Pre-intervention, LS-MRI orders were placed via the CPOE system but did not trigger CDS. Only PCPs received the intervention, triggered based on their primary practice affiliation; medical and surgical subspecialists and emergency physicians placed orders for LS-MRI without receiving CDS.

In addition to CDS, our intervention included two components we termed accountability tools. The first was a mandatory near real-time peer-to-peer telephonic consultation with a radiologist or internist familiar with the evidence before order completion when the orderer ignored a 'not indicated' CDS alert. The orderer could alternatively avoid the peer-to-peer consultation workflow by cancelling the order. As a second accountability tool, quarterly practice pattern variation reports were sent to individual PCPs, depicting their LS-MRI utilization (number of LS-MRIs ordered per number of LBP-related visits) in comparison to peers.

Data collection and sources

Patient demographics and imaging use in the study cohort were collected from electronic medical records. Any MRI ordered on the day of primary care visit from a primary care site, or an LS-MRI order from a specialist or PCP within 30 days after the date of primary care visit, was attributed to the visit. Similar data of patient demographics and MRI of any body part ordering patterns in the control cohort was collected directly from the NAMCS database. Due to the design of the NAMCS survey, the specific body part of MRI and subsequent imaging orders from specialists were not available.

To evaluate whether LS-MRI orders were guideline-adherent in the study cohort, two board-certified attending physicians reviewed the medical records. Based on power calculation with alpha of 0.05, power of 0.8, and confidence interval of 15%, charts of two hundred randomly-selected patients with visits in the pre- and post-intervention periods (100 in each group) were reviewed to determine whether each study ordered was in adherence with the ACP/APS guidelines. Records were also reviewed to verify concordance between physician note documentation and CPOE system input. For example, a case would be considered not concordant if review of the physician note showed that an order was guideline-adherent while the LS-MRI order requisition (entered into the CPOE system) illustrated otherwise.

Statistical analyses

The primary outcome measure in our study cohort was the intensity of LSMRI use, defined as the number of completed LS-MRI examinations that were ordered by PCP per LBP-related visit. As a secondary measure, we also examined the intensity of MRI of any body part use, an element that is captured by the NAMCS survey, thus allowing us to compare utilization in the study cohort to that of a concurrent control. MRI use intensity in the pre-intervention period was compared to that post-intervention. For MRI of any body part, the change in MRI use intensity between the pre- and post-intervention periods was compared to the control cohort to account for secular confounders. We also examined in the study cohort the rates of utilization of LS-MRI by both primary care and specialists, adherence rate to

ACP/APS guideline for LS-MRI use, as well as the rate of follow-up LBP-related primary care visits within 30 days of the index visit. The 30-day follow-up timeframe was based on the ACP guideline recommendation of follow-up within 4 weeks¹³. Analyses were performed using JMP 10 (SAS Institute, Cary, NC). Chi-square and t-tests were used to assess pre- and post-intervention differences. To adjust for demographic differences between the study and control cohorts, a logistic regression was performed. A two-tailed p-value of <0.05 was defined as statistically significant.

Results

Between 2007 and 2010, there were 21,445 LBP-related primary care visits (8,437 pre-intervention and 13,008 post-intervention) by patients aged 18 or older in the study cohort. There were 2,240 (945 pre-intervention and 1,295 post-intervention) LBP-related primary care visits in the control cohort. Overall, 3.7% of primary care encounters in the pooled study and control cohorts were LBP-related (3.6% in the study cohort; 6.5% in the control). In the study cohort, the mean patient age was 53.0 years and 69.7% of patients were female. This represented a slighter older and more female-concentrated cohort than the control (50.5 years mean age, 57.3% female). Details of the patient demographic characteristics of the study and control cohorts are shown in Table 1.

Overall, 920 (4.3%) LBP-related primary care visits were associated with a LS-MRI ordered from the primary care practice on the day of visit in the study cohort. During the study period, we observed a decreased intensity in the use of LS-MRI among patients with LBP in the study cohort. In the pre-intervention phase, 5.3% of LBP visits (443/8437) were associated with a LS-MRI order; after our CDS-enabled interventions were implemented, utilization decreased by a relative 30.2% ($p<0.0001$), to a rate of 3.7% of LBP-related primary care visits ($n=477/13,008$). The approximately 30% relative decrease in LS-MRI utilization intensity in the study cohort post-intervention persisted even after accounting for baseline demographic differences in age, gender, and race between the study and control cohorts (Adjusted Odds Ratio 0.68, $p<0.0001$) (Table 2).

In the study cohort, 1,251 (5.3%) LBP-related primary care visits were associated with and order for an MRI of any body part. 73.5% of these MRIs were for lumbar-spine (920/1251). In the pre-intervention phase, 6.5% of LBP visits ($n=546/8437$) were associated with an MRI of any body part order; after intervention, the utilization of MRI of any body part decreased by a relative 30.8% ($p<0.0001$), to a rate of 4.5% of LBP-related primary care visits ($n=584/13,008$). In contrast, in the control cohort of NAMCS surveyed visits, the use of MRI of any body part did not change significantly ($p=0.712$) over the same timeframe (Figure 2). Similar to the primary outcome measure, the approximately 30% relative decrease in MRI of any body part utilization intensity in the study cohort post-intervention persisted even after accounting for baseline demographic differences in age, gender, and race between the study and control cohorts (Adjusted Odds Ratio 0.67, $p<0.0001$) (Table 2).

Table 3 depicts results for the tertiary outcome measures in the study cohort. There was a statistically significant relative increase of 22.7% (2.2% vs. 2.7%) in the rate of LS-MRI ordered by outpatient specialists (e.g., orthopedics, neurosurgery, rheumatology, etc.) within

30 days of a patient's index primary care visit ($p=0.0292$), which suggests that some of the LS-MRI use may have simply shifted to ordering by specialists. However, the overall percentage of LBP-related visits that resulted in a LS-MRI within 30 days of the index visit, remained significantly different in the pre- and post- intervention periods, even after accounting for exams that were ordered by specialists (8.9% vs. 7.8%, relative 12% decrease, $p=0.0023$).

In the study cohort, pre-intervention, 78% of LS-MRI orders were adherent to the evidence-based guideline, compared to 96% after intervention ($p=0.0002$). There was 89% (89/100) concordance between users' input into the CPOE system and the PCP clinic notes. The majority of the non-concordance was due to incomplete documentation ($n=7$ of 100; 7%) of clinical information in clinic notes compared to LS-MRI order. In 4/100 instances (4%), discordance was noted with conflicting clinical information entered in clinic notes compared to LS-MRI order.

Discussion

Recent healthcare reform efforts aim to improve quality, reduce waste, and enhance value²¹. Clinical guidelines have been proposed as a way to increase clinical efficiency and minimize inappropriate care^{22,23}. However, wide gaps between evidence and practice exist^{24,25,26}, and significant implementation barriers persist²⁷. In our study, we found that implementing a multi-faceted intervention including education using CDS and accountability tools was associated with a 32-33% decrease in LS-MRI and MRI of any body part use intensity while improving guideline-adherent practice. Given national promotion of adoption and meaningful use of HIT²⁸, these findings support the notion that HIT-enabled interventions using CDS can help improve quality and reduce waste by promoting evidence-based practice for diagnostic imaging.

Comparing to previous studies of imaging CDS, we observed a slightly greater improvement in guideline adherence than others^{29,30}. In a time-series study, making appropriateness guidelines available in a CPOE system in two European emergency departments decreased non-conforming radiology orders from 33.2% to 26.9% ($p=0.0001$)³¹. Blackmore et al found that the use of imaging CDS was associated with a 23% decrease in the utilization rate of lumbar MRI for low back pain in a retrospective cohort study²⁹. Although HIT in the form of CDS likely played a critical role in our intervention, we believe our higher guideline adherence rates were due to the combined effect of CDS and complementary accountability tools. These tools highlight to providers the importance of quality and value, and the quarterly practice variation reports and peer-to-peer consultation likely reinforced this message regularly.

Although we found an adjusted 32% reduction in LS-MRI utilization on the same day as the index primary care visit post-intervention, it is important to note that part of this decrease did not necessarily translate into reduction in use of LS-MRI in the 30-day interval post the index primary care visit. Our findings show that some patients still underwent LS-MRI studies, requested either through the PCPs or specialists, within 30 days of the index visit. Some of the studies that were ordered through primary care subsequently may represent care

that is guideline-adherent, performed in patients whose symptoms persisted despite conservative medical management. Yet, we also noted that the LS-MRI utilization rate actually increased, from 2.2% to 2.7% ($p=0.0292$), when examining those ordered by a specialist. This shift of ordering pattern to specialty providers in which the intervention was not implemented may have offset some of the MRI use reductions ordered by PCPs. Further research is needed to examine the impact of our intervention in non-primary care settings.

Our study has several limitations. First, we could not measure the specific impact of individual components of our intervention (i.e., CDS, quarterly reporting, and peer-to-peer consultation) on ordering behavior. However, we chose to implement a multi-faceted intervention strategy as previous research has found that interventions that target multiple behavioral factors are more likely to result in change³²⁻³⁴. Second, it is possible that our observed decline in imaging use may not be solely due to our intervention but also confounders, such as increased public awareness of harm associated with inappropriate imaging, and the publication of the ACP guidelines during the study period. However, small-to-no decline in imaging use was observed in the control cohort, which argues that guideline publication alone may not be an effective intervention for changing clinical practice³⁵. Due to design of the NAMCS survey, body-specific imaging data (i.e., LS-MRI) was not available. The difference in data collection methodology between the study and control cohorts (health records in the study cohort vs. survey in the control cohort) represents another limitation. However, other studies over the same time period have found that MRI use in the Medicare population based on claims data³⁶ is consistent with that revealed in NAMCS surveys. Additionally, our study was performed at a single academic medical center; thus the generalizability of our findings in other settings is unclear. Furthermore, we used billing data in cohort identification, which may not have captured all eligible patients. Only orders placed through our institution were included, potentially underestimating imaging for our patients at outside institutions. However, such occurrences are estimated to be small and are thus unlikely to influence our findings. Finally, we did not assess the impact of our intervention on patient or provider satisfaction which will be an important topic for future enquiry to help define best practices for implementing CDS-enabled interventions.

Conclusion

A multi-faceted intervention of evidence-CDS, supplemented by near real-time technology-enabled consequences for overriding CDS and quarterly practice pattern variation reporting, may be a valuable strategy to reduce potentially inappropriate imaging.

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Appendix

Appendix Table 1

ICD9 Inclusion Codes for Cohort Identification

ICD9 Code	Description
307.89	Psychogenic backache
721.3	Lumbosacral spondylosis w/o myelopathy
721.5	Kissing spine (Baastrup Disease)
721.6	Ankylosing vertebral hyperostosis
721.7	Traumatic spondylopathy
721.8	Other allide disorders of spine
721.9	Spondylosis of unspecified site w/o myelopathy
722.1	Displacement of thoracic or lumbar disc w/o myelopathy
722.2	Degeneration of intervertebral disc, site unspecified
722.3	Schmorl's bides
722.5	Degeneration of thoracic or lumbar intervertebral disc
722.6	Degeneration of intervertebral disc, site unspecified
722.9	Other and unspecified disc disorder of unspecified region
724	Other and unspecified disorders of back
724.0	Spinal stenosis, not cervical
724.1	Pain in thoracic spine
724.2	Lumbago
724.3	Sciatica
724.4	Back pain with radiation, unspec
724.5	Backache, unspecified
724.6	Disorders of sacrum (including lumbosacral junction)
733.10	Pathologic fractures, unspecified site
733.13	Pathologic fractures: vertebrae
733.93	Stress fracture of other bone
738.4	Acquired spondylolisthesis
738.5	Other acquired deformity of back or spine
739.2	Nonallopathic lesions-thoracic, not elsewhere classified
739.3	Nonallopathic lesions-lumbar, not elsewhere classified
739.4	Nonallopathic lesions-sacral, not elsewhere classified
756.11	Spondylolysis
756.12	Spondylolisthesis
846.0	Lumbosacral sprain
846.1	Sacroiliac (ligament) sprain
846.2	Sacrospinatus (ligament) sprain
846.3	Sacrotuberous (ligament) sprain
846.8	Other specified sites of sacroiliac region sprain
846.9	Unspecified site of sacroiliac region sprain
847.2	Thoracic sprain
847.3	Sacral sprain

ICD9 Code	Description
847.9	Sprain – unspecified site of back

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Clinical Significance

- Evidence-based clinical decision support (CDS), with embedded consequences for ignoring evidence, was associated with a statistically significant decrease in lumbar-spine MRI use in patients with low back pain.
- A targeted CDS-enabled intervention was associated with an absolute increase in guideline adherence rate in the use of MRI.
- Health information technology tools can help improve quality and reduce waste by promoting evidence-based practice for diagnostic imaging.

DECISION SUPPORT

Based on published evidence MRI is not recommended in the absence of clinical "red flags". If symptoms are disabling, consider consultation with the comprehensive spine center at 617 732-6600.

Clinical guidelines from the American College of Physicians and American Pain Society: Clinicians should perform diagnostic imaging and testing for patients with low back pain when severe or progressive neurologic deficits are present or when serious underlying conditions are suspected on the basis of history and physical examination (strong recommendation, moderate-quality evidence).

Please note that the information is presented to assist you in providing care to your patients. We do not provide advice regarding the appropriateness of coding, billing or claims processing. We make no representations regarding the payment or reimbursement for services rendered.



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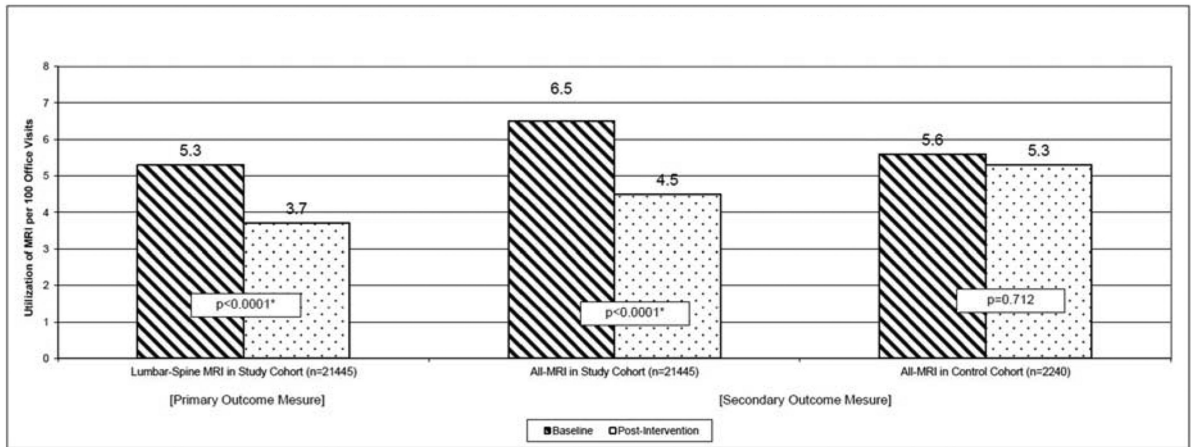


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Utilization of Magnetic Resonance Imaging in Back-Pain Related Primary Care Office Visits

Table 1

Patient Characteristics of Study and Control Cohorts

Characteristic	Study Cohort (n=21,445)	Control Cohort (n=2,240)	P-value
Gender			
Female (n; %)	14,950 (69.7%)	1,283 (57.3%)	<0.0001*
Age (years: average \pm standard dev)	53.0 \pm 15.6	50.5 \pm 15.8	<0.0001*
Race / Ethnicity (n; %)			<0.0001*
Caucasian	13,563 (63.2%)	1,259 (56.2%)	
Black / African American	3,785 (17.7%)	274 (12.2%)	
Hispanic	2,080 (9.7%)	190 (8.5%)	
Asian	614 (2.9%)	27 (1.2%)	
Other	1,403 (6.5%)	490 (21.9%)	

* Denotes statistical significance

Table 2

Results of Logistic Regression on the Use of Magnetic Resonance Imaging Controlling for Patient Characteristics in Study Cohort

Variable	Odds Ratio	95% CI	p-value
Primary Outcome Measure: LS-MRI Utilization			
Patient Age (by year)	1.008 per year	1.004-1.013	0.0002 *
Patient Gender (reference = Female)	1.23	1.07-1.42	0.004 *
Race/Ethnicity (reference = Caucasian)			0.150
Asian	0.99	0.65-1.45	
Black/African American	0.79	0.65-0.95	
Hispanic	1.05	0.83-1.31	
Other	0.98	0.74-1.28	
Intervention	0.68	0.59-0.77	<0.0001 *
Secondary Outcome Measure: MRI of any body part Utilization			
Patient Age (by year)	1.008 per year	1.005-1.012	<0.0001 *
Patient Gender (reference = Female)	1.26	1.11-1.42	0.0004 *
Race/Ethnicity (reference = Caucasian)			0.178
Asian	1.11	0.77-1.55	
Black/African American	0.83	0.69-0.98	
Hispanic	1.06	0.86-1.30	
Other	1.01	0.79-1.28	
Intervention	0.67	0.59-0.75	<0.0001 *

CI = confidence

LS = Lumbar spine

MRI = magnetic resonance imaging

* denotes statistical significance

Table 3Analysis of Tertiary Outcome Measures in the Study Cohort^A

Outcome Measure	Pre-Intervention	Post-Intervention	% Change	p-value
Lumbar Spine MRI ordered by any outpatient providers within 30 days of index primary care visit	753 (8.9%)	1009 (7.8%)	-12.3%	0.0023 *
Lumbar Spine MRI ordered by specialty clinics within 30 days	188 (2.2%)	352 (2.7%)	+22.7%	0.0292 *
Lumbar Spine MRI ordered by primary care outpatient providers within 30 days	565 (6.7%)	657 (5.1%)	-23.9%	<0.001 *
Follow-up PCP visit within 30 days	855 (10.1%)	1224 (9.4%)	-6.9%	0.080
Guideline adherence rate in the use of Lumbar Spine MRI based on manual chart review	78/100 (78%)	96/100 (96%)	+23.1%	0.0002 *

PCP = primary care physician

MRI = magnetic resonance imaging

* denotes statistical significance

^A Due to design of NAMCS survey, tertiary outcome measure was not possible in the control cohort