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Effects of Including Epidemiologic Data in Lumbar Spine Imaging Reports on Prescribing Non-Opioid Medications for Pain

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BACKGROUND: Information on the prevalence of common imaging findings among patients *without* back pain in spine imaging reports might affect pain medication prescribing for patients *with* back pain. Prior research on inserting this text suggested a small reduction in opioid prescribing.

OBJECTIVE: To evaluate the effect of epidemiologic information in spine imaging reports on non-opioid pain medication prescribing for primary care patients with back pain.

DESIGN: Post hoc analysis of the Lumbar Imaging with Reporting of Epidemiology cluster-randomized trial.

PARTICIPANTS: A total of 170,680 patients aged ≥ 18 years from four healthcare systems who received thoracolumbar, lumbar, or lumbosacral spine imaging from 2013 to 2016 and had not received a prescription for non-opioid pain medication in the preceding 120 days.

INTERVENTION: Text of age- and modality-specific epidemiologic benchmarks indicating the prevalence of common findings in people without back pain inserted into thoracolumbar, lumbar, or lumbosacral spine imaging reports at intervention clinics.

MAIN MEASURES: Primary outcomes: any non-opioid prescription within 90 days after index imaging, overall, and by sub-class (skeletal muscle relaxants, NSAIDs, gabapentinoids, tricyclic antidepressants, benzodiazepines, duloxetine). Secondary outcomes: count of non-opioid prescriptions within 90 days, overall, and by sub-class.

KEY RESULTS: The intervention was not associated with the likelihood of patients receiving at least one prescription for new non-opioid pain-related medications, overall (adjusted OR, 1.02; 95% CI, 0.97–1.08) or by sub-class. The intervention was not associated with the number of prescriptions for any non-opioid medication (adjusted incidence rate ratio [IRR], 1.02; 95% CI, 0.99–1.04). However, the intervention was associated with more new prescriptions for NSAIDs (IRR, 1.12) and tricyclic antidepressants (IRR, 1.11).

CONCLUSIONS: Inserting epidemiologic text in spine imaging reports had no effect on whether new non-opioid pain-related medications were prescribed but was associated with the number of new prescriptions for certain non-opioid sub-classes.

TRIAL REGISTRATION: ClinicalTrials.gov identifier: NCT02015455

KEY WORDS: analgesics, non-narcotic; radiology; spine; health services research.

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INTRODUCTION

Low back pain is the fifth most frequent reason for office visits in the USA and is a leading cause of years lived with disability globally and in the USA.[1,2] The use of healthcare services for chronic low back pain has been increasing over time.[3] Moreover, spine imaging is over-used in the USA, despite national guidelines recommending it only for those patients with low back pain who have certain clinical indications such as signs or symptoms indicating serious underlying conditions.[4–6] Common degenerative spine imaging findings (e.g., disc height loss, bulging disks) are only weakly associated with

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symptoms;[7,8] nevertheless, incidental, non-clinically meaningful imaging findings can result in patients and providers pursuing costly, ineffective, and potentially harmful treatments. Prior studies suggest that including information on the prevalence of common imaging findings among patients *without* back pain in spine imaging reports may reduce potentially unnecessary subsequent treatments in people with back pain, plausibly by reminding providers that such findings are common in those without back pain and are only weakly linked to symptoms.[9,10]

Our prior observational work found that patients whose physicians received epidemiologic text providing age- and modality-specific benchmarks of specific findings in their thoracic or lumbar spine magnetic resonance (MR) imaging reports were less likely to receive an opioid prescription at their follow-up clinic visit than were patients whose physicians had not received epidemiologic information.[11] In addition, a large, prospective randomized controlled trial, the Lumbar Imaging with Reporting of Epidemiology (LIRE) trial, found a small but statistically significant reduction (odds ratio (OR), 0.95; 95% confidence interval (CI), 0.90–0.99) in the likelihood of receiving an opioid prescription within 90 days among patients with spine imaging whose providers were randomized to receive the epidemiologic text versus patients whose providers were not randomized to receive the text.[12] A total of 29% of patients overall received an opioid prescription within 90 days in the LIRE trial.

However, it is unknown how insertion of such epidemiologic text in spine imaging reports might affect prescribing of medications other than opioids for pain. On one hand, after viewing the epidemiologic text in the spine imaging report, primary care providers (PCPs) could adopt a more conservative global approach to the prescribing of all pain-related medications. On the other hand, it is possible that a corollary to a reduction in opioid prescribing—as reported in the primary outcomes of the LIRE trial—might be an increase in the prescribing of non-opioid medications for pain. This could be due to the intervention resulting in a reduction in providers' appraisal of patients' pain as a serious problem warranting treatment with opioid therapy but at the same time providers wanting to provide some pharmacological treatment in response to the patient's concerns. Our objective in this post hoc, hypothesis-generating analysis of the LIRE trial was to evaluate the effect of inserting epidemiologic text in spine imaging reports on prescribing non-opioid medications for pain in primary care patients.

METHODS

Setting and Data Sources

We conducted a post hoc analysis of data obtained from the LIRE study. LIRE was a pragmatic, multi-center, stepped-wedge, cluster-randomized trial conducted by assigning primary care clinics within four large healthcare systems to different start dates for receiving imaging reports containing several additional lines of text describing age- and modality-appropriate epidemiologic benchmarks for the prevalence of common degenerative imaging findings in individuals without back pain. Clinics received standard imaging reports prior to their assigned intervention date. The study protocol was published previously.[9]

Study Participants and Eligibility Criteria

Clinics and their patients at four integrated healthcare systems were enrolled: Kaiser Permanente, Northern California; Henry Ford Health System, Detroit, MI; Kaiser Permanente Washington, formerly Group Health Cooperative, Seattle, WA; and Mayo Clinic Health System, Rochester, MN. These systems have comprehensive electronic medical record (EMR) systems for capture of healthcare utilization and prescribing data.

At each healthcare system, we identified adult primary care clinics and their associated providers. We defined a LIRE provider as a PCP who was based at one clinic providing primary care and ordered at least one qualifying index imaging examination during the study period. We enrolled patients ≥ 18 years old if a PCP from an eligible clinic ordered a diagnostic imaging test of the thoracolumbar, lumbar, or lumbosacral spine between October 1, 2013, and September 30, 2016. Unless the patient had signed a declaration opting out of all research studies, we included all patients receiving eligible thoracolumbar, lumbar, or lumbosacral spine imaging studies at participating clinics who had not had spine imaging within the prior 12 months. For the current analysis, we were interested in the effect of the intervention on incident (new) non-opioid prescribing. Patients were excluded if they received a prescription (from any provider) for any non-opioid within 120 days before the date that the imaging report was finalized. Patients were not excluded based on prescription of any opioid. Prescriptions written between the date the image occurred and prior to the image report being finalized were not counted as prescriptions in the 120 days prior to index nor were they counted as outcomes. Prescriptions written on the same day as the image report being finalized were counted as outcomes.

All participating institutional review boards agreed that our study was minimal risk and granted waivers of both consent and Health Insurance Portability and Accountability Act (HIPAA) authorization.

LIRE Trial Randomization

We used a stepped-wedge randomization scheme, randomly assigning clinics at each system to begin receiving the intervention at one of five calendar times: April 2014, October 2014, April 2015, October 2015, and April 2016. We created tertiles of the number of PCPs in the clinics and from each tertile we randomly selected clinics using urn-based randomization (without replacement) stratified by system and clinic

size. Thus, clinics of small, medium, and large sizes were equally represented in each randomization wave.

Intervention

The intervention text consisted of age- and modality-specific epidemiologic benchmarks indicating the prevalence of common findings in people without back pain (Online Supplemental Methods).[12–14] Using a fully automated approach through either the radiology information system or EMR, the intervention text was inserted into thoracolumbar, lumbar, or lumbosacral spine imaging reports at intervention clinics. PCPs in control clinics received the usual imaging reports without the intervention text.

Baseline Measures

From the EMR, we assembled diagnosis (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM] and Tenth Revision [ICD-10-CM]) and procedure (Current Procedural Terminology; CPT) data for patients from the 12 months prior to index imaging. We collected the following baseline variables: patient age category (18–39, 40–60, and ≥61 years), Charlson comorbidity index category (0, 1, 2, and ≥3),[15,16] sex, index imaging modality (X-ray, CT, or MRI), study site, and clinic size. To assess trends over time in the rates of new prescriptions for non-opioid pain medications, overall, and for each of the non-opioid sub-classes, we also measured calendar time in 6-month intervals. Furthermore, we also extracted findings on the index images from radiology text reports using a validated natural language processing approach.[17] These were categorized into three mutually exclusive groups:[1] no findings;[2] findings referenced in the intervention text that were likely clinically unimportant (e.g., disc bulge, disc space narrowing, annular fissure); and[3] findings that were likely to be clinically important (e.g., moderate-severe spinal canal stenosis, nerve root compression, disc extrusion).

Outcome Measures

Each health system provided data from their electronic pharmacy databases for all prescription orders for study patients throughout the study period. A pharmacist (ZAM) reviewed the prescription data and identified each non-opioid medication of interest using drug information databases (IBM Micromedex® and UpToDate®) and categorized the non-opioid medications into their respective sub-classes (Appendix Table 1). Oral and topical dosage forms were included for analysis.

Our primary outcomes were non-opioid pain medication prescriptions (none versus any) by LIRE providers (although not necessarily the same provider who ordered the patient's index image) for a study patient within the first 90 days after the index imaging report for the patient was finalized, overall as well as by sub-class. We did not assess whether prescriptions were filled because the intervention targeted physicians, not patients. Moreover, incomplete prescription fill data across sites prevented analysis of such outcomes. We defined non-opioid, pain-related medications as skeletal muscle relaxants, non-steroidal anti-inflammatory drugs (NSAIDs), gabapentinoids, tricyclic antidepressants, benzodiazepines, and duloxetine. Our secondary outcomes were the total counts of the number of non-opioid prescriptions by LIRE providers within the first 90 days, overall as well as by sub-class.

Statistical Analysis

We calculated descriptive statistics for prescriptions for each non-opioid medication by demographic and clinical variables. We also examined the number and percent of patients who had 1, 2, or >2 prescriptions for each non-opioid medication within 90 days after the imaging report finalization date.

To evaluate the impact of inserting epidemiologic data into an imaging report, we used generalized linear mixed effects models with robust standard errors for our primary outcome measures of whether patients had prescriptions for each of the non-opioids within 90 days after the imaging report finalization date. We used zero-inflated Poisson regression mixed effects models for our secondary outcome measures of the counts (including 0's) of how many prescriptions were written within 90 days. All models were adjusted for patient age category, Charlson comorbidity index category, sex, index imaging modality, study site, clinic size, type of findings on index image, and calendar time. We also assessed secular trends in prescribing non-opioids overall and by non-opioid sub-class using the variable, calendar time. We included random effects for the study clinic and for the provider who ordered the index image. All analyses employed the intention-to-treat principle of analyzing each participant according to their clinic's randomization status. SAS software version 9.4 (Cary, NC, USA) was used for all analyses.

RESULTS

Study Sample

Table 1 shows characteristics of patients and image-ordering providers in each study arm. The intervention and control groups were similar for these characteristics. Of the 238,886 patients who met the eligibility criteria for the LIRE trial, 170,680 patients did not receive a prescription for a non-opioid pain medication in the 120 days prior to their index image finalization date and thus were included in the analyses of the primary outcomes (Appendix Table 2). Of these, 48,697 (29%) were prescribed at least one new non-opioid pain-related medication within 90 days after the index image (Appendix Table 3). The most common non-opioid pain medication sub-class prescribed within 90 days was skeletal muscle relaxants (14% of patients), followed by prescription

Table 1 Characteristics of Patients and Image-Ordering Providers Stratified by Presence of Intervention Text on Index Lower Back Imaging Report

	Intervention text present *N*=86,984	Intervention text absent *N*=83,696
Patient characteristics		
Age, years		
18–39	16,438 (19%)	15,654 (19%)
40–60	31,107 (36%)	30,854 (37%)
>60	39,439 (45%)	37,188 (44%)
Comorbidity		
0	58,116 (67%)	55,693 (67%)
1	14,091 (16%)	13,579 (16%)
2	8043 (9%)	7876 (9%)
3+	6734 (8%)	6548 (8%)
Female	47,784 (55%)	46,536 (56%)
Index image type		
X-ray	73,589 (85%)	69,699 (83%)
CT	265 (0.3%)	272 (0.3%)
MRI	13,130 (15%)	13,725 (16%)
Site		
Site (A)	5238 (6%)	4897 (6%)
Site (B)	72,311 (83%)	68,507 (82%)
Site (C)	5617 (6%)	5885 (7%)
Site (D)	3818 (4%)	4407 (5%)
Race		
Asian	10,712 (12%)	10,643 (13%)
Black/African-American	8006 (9%)	8362 (10%)
Native Hawaiian/Pacific Islanders	516 (0.6%)	666 (0.8%)
Native American/Alaska Native	551 (0.6%)	525 (0.6%)
Multiracial	386 (0.4%)	326 (0.4%)
White	55,430 (64%)	52,924 (63%)
Unknown	11,383 (13%)	10,250 (12%)
Hispanic	13,287 (15%)	12,865 (15%)
Insurance status		
Medicare	33,020 (38%)	31,415 (38%)
Medicaid/state-subsidized	4005 (5%)	3405 (4%)
Commercial (including Medicare supplements)	48,410 (56%)	47,268 (56%)
Veterans Administration	96 (0.1%)	78 (0.1%)
Self-pay	444 (0.5%)	556 (0.7%
Unknown/missing	1009 (1%)	974 (1%)
Image finding status		
None	20,861 (24%)	20,872 (25%)
Clinically unimportant finding	56,249 (65%)	52,559 (63%)
Clinically important finding	9874 (11%)	10,265 (12%)
Image-ordering provider characteristics		
Provider mean age (IQR)	49.3 (43–55)	49.5 (43–56)
Provider type		
Doctor osteopathy	6351 (7%)	5762 (7%)
Medical doctor	77,752 (89%)	75,157 (90%)
Physician assistant/nurse practitioner	2881 (3%)	2777 (3%)
Provider female	44,583 (51%)	44,945 (54%)

NSAIDs (8%), gabapentinoids (6%), tricyclic antidepressants (4%), and benzodiazepines (4%).

Primary Outcomes

Inserting epidemiologic text in spine imaging reports of primary care patients did not have a significant effect on prescribing non-opioid pain-related medications as measured dichotomously (i.e., any vs. none). This was true for the model including prescription of any non-opioid medication (adjusted OR, 1.02; 95% CI, 0.97–1.08), as well as for each non-opioid medication sub-class (skeletal muscle relaxant: adjusted OR 1.01, 95% CI 0.94–1.07; NSAID: adjusted OR 1.04, 95% CI 0.95–1.13; gabapentinoids: adjusted OR 1.01, 95% CI 0.93–1.11; tricyclic antidepressants: adjusted OR 1.04, 95% CI 0.94–1.15; benzodiazepine: adjusted OR 1.02, 95% CI 0.93–1.12) (Table 2). Of note, the model for duloxetine did not converge due to low numbers so duloxetine was not evaluated as its own sub-class, but was included in the any non-opioid model.

Secondary Outcomes

Inserting epidemiologic text in spine imaging reports of patients did not have a significant effect on the total number of new non-opioid pain-related prescriptions (adjusted incidence rate ratio [IRR] 1.02, 95% CI 0.99–1.04). However, the intervention had effects on non-opioid sub-classes (Table 2). The intervention was associated with 12% and 11% increases in the number of new prescriptions for NSAIDs (adjusted IRR 1.12, 95% CI 1.07–1.18) and tricyclic antidepressants (adjusted IRR 1.11, 95% CI 1.03–1.20), respectively. The

Table 2 Effect of LIRE Intervention on Incident Non-Opioid Pain-Related Prescriptions Within 90 Days of Index Date, Overall, and by Medication Sub-class (*N*=170,680)

	Any non-opioid	Skeletal muscle relaxant	NSAID	Gabapentinoid	Tricyclic anti-depressant	Benzodiazepine
Primary outcomes: Any prescription at 90 days[a]	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
LIRE intervention text present	1.02 (0.97–1.08)	1.01 (0.94–1.07)	1.04 (0.95–1.13)	1.01 (0.93–1.11)	1.04 (0.94–1.15)	1.02 (0.93–1.12)
Secondary outcome: Count of prescriptions at 90 days	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)
LIRE intervention text present	1.02 (0.99–1.04)	0.97 (0.94–1.00)	1.12 (1.07–1.18)	1.06 (0.99–1.12)	1.11 (1.03–1.20)	0.98 (0.91–1.05)

CI, confidence interval; IRR, incidence rate ratio; OR, odds ratio
All models adjusted for age, comorbidity, sex, index image type, site, clinic size, type (if any) of findings on index image, and time (years). The model for duloxetine did not converge due to low numbers
[a]Odds ratios and 95% confidence intervals for time (in years) variable: any non-opioid, 0.98 (0.96–0.995); skeletal muscle relaxant, 0.97 (0.95–1.00); NSAID, 1.01 (0.97–1.04); gabapentinoid, 1.11 (1.07–1.16); tricyclic antidepressant, 0.89 (0.85–0.94); benzodiazepine, 0.90 (0.86–0.95)

Table 3 Number and Percentage of Patients with 0, 1, 2, or >2 Non-Opioid Prescriptions Within 90 Days After Imaging, Stratified by Presence of Intervention Text on Index Lower Back Imaging Report

Non-opioid medication class	0 Prescriptions		1 Prescription		2 Prescriptions		>2 Prescriptions	
	Intervention text present *N*=86,984	Intervention text absent *N*=83,696	Intervention text present *N*=86,984	Intervention text absent *N*=83,696	Intervention text present *N*=86,984	Intervention text absent *N*=83,696	Intervention text present *N*=86,984	Intervention text absent *N*=83,696
Any non-opioid	61,922 (71%)	60,061 (72%)	17,367 (20%)	16,188 (19%)	5385 (6%)	5136 (6%)	2310 (3%)	2311 (3%)
Skeletal muscle relaxant	74,570 (86%)	71,699 (86%)	10,838 (12%)	10,250 (12%)	1229 (1%)	1368 (2%)	347 (0.4%)	379 (0.5%)
NSAID	79,369 (91%)	76,871 (92%)	6536 (8%)	5820 (7%)	908 (1%)	851 (1%)	171 (0.2%)	154 (0.2%)
Gabapentinoid	82,475 (95%)	79,952 (96%)	3691 (4%)	2955 (4%)	625 (0.7%)	610 (0.7%)	193 (0.2%)	179 (0.2%)
Tricyclic anti-depressant	83,888 (96%)	80,683 (96%)	2511 (3%)	2370 (3%)	476 (0.6%)	527 (0.6%)	109 (0.1%)	116 (0.1%
Benzodiazepine	84,271 (97%)	80,690 (96%)	2240 (3%)	2422 (3%)	343 (0.4%)	402 (0.5%)	130 (0.2%)	182 (0.2%)

intervention was not significantly associated with the number of new prescriptions for skeletal muscle relaxants (adjusted IRR 0.97, 95% CI 0.94–1.00), gabapentinoids (adjusted IRR 1.06, 95% CI 0.99–1.12), or benzodiazepines (adjusted IRR 0.98, 95% CI 0.91–1.05). Among patients who were prescribed non-opioid pain-related medications within 90 days, a large majority were written only one prescription (Table 3).

Secular Trends in Non-Opioid Prescribing

Over the years of the study, decreases were observed in new non-opioid prescriptions overall (adjusted OR per year, 0.98; 95% CI, 0.96–0.995), tricyclic antidepressants (adjusted OR per year, 0.89; 95% CI, 0.85–0.94), and benzodiazepines (adjusted OR per year, 0.90; 95% CI, 0.86–0.95) (Table 2, footnote). In contrast, new prescribing of gabapentinoids increased over time (adjusted OR per year, 1.11; 95% CI, 1.07–1.16).

DISCUSSION

In post hoc analyses of the LIRE pragmatic, stepped-wedge, cluster randomized trial of inserting epidemiologic data into thoracolumbar, lumbar, or lumbosacral spine imaging reports, we observed no significant effect of the intervention on new prescriptions for non-opioid medications (measured dichotomously or as a count) within 90 days after imaging report finalization. Furthermore, the intervention did not affect new prescriptions for non-opioid pain-related medication subclasses as measured dichotomously. However, we observed small but statistically significant effects of the intervention on the number of new prescriptions for certain non-opioid medication sub-classes. Specifically, the intervention was associated with an increase in the number of prescriptions for tricyclic antidepressants and NSAIDs, even after controlling for secular trends in prescribing. The effect on continuous but not dichotomous variables may be due to the increased statistical power to detect differences in continuous outcomes between intervention groups.[18] However, it is also possible that the intervention had no effect on the likelihood of prescribing a non-opioid but did affect the prescribing behavior of PCPs who decided to prescribe a non-opioid.

It is not clear why the LIRE intervention was associated with an increase in the number of prescriptions for tricyclic antidepressants and NSAIDs. The LIRE trial's main results included a small but statistically significant reduction in opioid prescribing. In the context of a small reduction in opioid prescribing, our finding of a small increase in the number of prescriptions for tricyclic antidepressants and NSAIDs suggests a more liberal treatment approach with certain non-opioids. However, it is important to note that we did not formally test a substitution hypothesis. These results should be interpreted in the context of the incidence of multiple prescriptions within 90 days for each of these sub-classes; only 1.2% (N=2084) and 0.7% (N=1226) of patients received 2+ prescriptions for an NSAID and TCA, respectively, within 90 days. While uncommon, these results suggest that PCPs might have prescribed a shorter days supply, with closer monitoring. Yet, we do not have data on provider rationale to support this hypothesis so further research is needed. Our finding of no effect of the intervention on benzodiazepine prescriptions might be due to the fact that they are primarily prescribed for non-pain conditions (e.g., anxiety) and thus less likely to be prescribed for pain that may result from spine abnormalities. Finally, although we did not find a significant effect of the intervention on gabapentinoid prescribing, our analysis of secular trends in prescribing non-opioids showed an 11% increase per year in new prescribing of gabapentinoids, which is consistent with other research showing increasing use of these medications.[19,20]

This study has several limitations. First, we were unable to measure patient-reported outcomes (e.g., pain and function). Thus, we are unable to infer whether any effects of the intervention on prescribed medications affected patient symptoms. We were also unable to measure whether pain-related medications were prescribed for pain or for a different indication (e.g., anxiety). In addition, we assessed only prescriptions for NSAIDs; some PCPs might have recommended to their patients use of over-the-counter NSAIDs or did not write a prescription for an NSAID because they knew their patient was already taking an over-the-counter NSAID. The observed intervention effect could be biased in either direction by this limitation, and our findings might have differed if we had been able to incorporate over-the-counter medications. Furthermore, because we were interested in the effect of the intervention on new prescribing, we did not examine changes in prescribing for patients who had prior prescriptions of non-opioid pain-related medications (as these patients were excluded). It is also important to note that because we were interested in the effect of the intervention on prescribing, we did not measure whether patients filled their prescriptions. Finally, we did not have access to data that would enable us to examine whether the LIRE intervention affected PCPs' recommendations for non-pharmacological treatments such as physical therapy, acupuncture, and cognitive-behavioral therapy.

In conclusion, inserting epidemiologic text in spine imaging reports did not affect new prescriptions for non-opioid pain-related medications or the total number of new non-opioid prescriptions at 90 days after the index imaging report was finalized. However, the intervention was associated with increases in the number of new prescriptions for NSAIDs and tricyclic antidepressants. In light of the LIRE trial's main results, including a small but significant reduction in the likelihood of prescribing an opioid, these findings suggest that the intervention might have resulted in substitution of non-opioid pain-related medications for opioids. To better understand effects of inserting epidemiologic text in spine imaging reports on prescribing, future research should explore physician-level decision making for analgesic prescribing to patients receiving thoracolumbar, lumbar, or lumbosacral

spine imaging in primary care. Another potentially fruitful area for future research is the insertion of guideline-based treatment information tailored to spine imaging findings combined with other important clinical characteristics for certain patients.

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REFERENCES

1. **Chou R, Shekelle P.** Will this patient develop persistent disabling low back pain?. JAMA. 2010;303:1295–1302.
2. GBD 2017 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018;392:1789–858.
3. **Buchbinder R, Underwood M, Hartvigsen J, Maher CG.** The Lancet Series call to action to reduce low value care for low back pain: an update. Pain. 2020;161 (Suppl 1):S57-S64.
4. **Chou R, Qaseem A, Snow V, et al.** Diagnosis and treatment of low back pain: a joint clinical practice guideline from the American College of Physicians and the American Pain Society. Ann Intern Med 2007;147:478-91.
5. **Wáng YXJ, Wu AM, Ruiz Santiago F, Nogueria-Barbosa MH.** Informed appropriate imaging for low back pain management: a narrative review. J Orthop Translat 2018;15:21-34.
6. **Oliveira CB, Maher CG, Pinto RZ, et al.** Clinical practice guidelines for the management of non-specific low back pain in primary care: an updated overview. Eur Spine J 2018;27:2791-803.
7. **van Tulder MW, Assendelft WJ, Koes BW, Bouter LM.** Spinal radiographic findings and nonspecific low back pain: a systematic review of observational studies. Spine (Phila Pa 1976). 1997;22:427-34.
8. **Jarvik JG, Deyo RA.** Diagnostic evaluation of low back pain with emphasis on imaging. Ann Intern Med 2002;137:586-97.
9. **Jarvik JG, Comstock BA, James KT, et al.** Lumbar Imaging with Reporting of Epidemiology (LIRE)—protocol for a pragmatic cluster randomized trial. Contemp Clin Trials 2015;45:157-63.
10. **Fried JG, Andrew AS, Ring NY, Pastel DA.** Changes in primary care health care utilization after inclusion of epidemiologic data in lumbar spine MR imaging reports for uncomplicated low back pain. Radiology. 2018;287:563-9.
11. **McCullough BJ, Johnson GR, Martin BI, Jarvik JG.** Lumbar MR imaging and reporting epidemiology: do epidemiologic data in reports affect clinical management? Radiology. 2012;262:941-6.
12. **Jarvik JG, Meier EN, James KT, et al.** The effect of including benchmark data of common imaging findings in spine image reports: a stepped-wedge, pragmatic randomized trial. JAMA Netw Open 2020 [in press]
13. **Roland M, van Tulder M.** Should radiologists change the way they report plain radiography of the spine? Lancet. 1998;352:229-30.
14. **Brinjikji W, Luetmer PH, Comstock B, et al.** Systematic literature review of imaging features of spinal degeneration in asymptomatic populations. AJNR Am J Neuroradiol 2015;36:811-6.
15. **Charlson M, Szatrowski TP, Peterson J, Gold J.** Validation of a combined comorbidity index. J Clin Epidemiol 1994;47:1245-51.
16. **Quan H, Li B, Couris CM, et al.** Updating and validating the Charlson comorbidity index and score for risk adjustment in hospital discharge abstracts using data from 6 countries. Am J Epidemiol 2011;173:676-82.
17. **Tan WK, Hassanpour S, Heagerty PJ, et al.** Comparison of natural language processing rules-based and machine-learning systems to identify lumbar spine imaging findings related to low back pain. Acad Radiol 2018;25:1422-1432.
18. **Altman DG, Royston P.** The cost of dichotomising continuous variables. BMJ. 2006;332:1080.
19. **Johansen ME.** Gabapentanoid use in the United States 2002 through 2015. JAMA Intern Med 2018;178:292-294.
20. **Montastruc F, Loo SY, Renoux C.** Trends in first gabapentin and pregabalin prescriptions in primary care in the United Kingdom, 1993-2017. JAMA. 2018;320:2149-2151.