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REVIEW ARTICLE

Imaging versus no imaging for low back pain: a systematic review, measuring costs, healthcare utilization and absence from work

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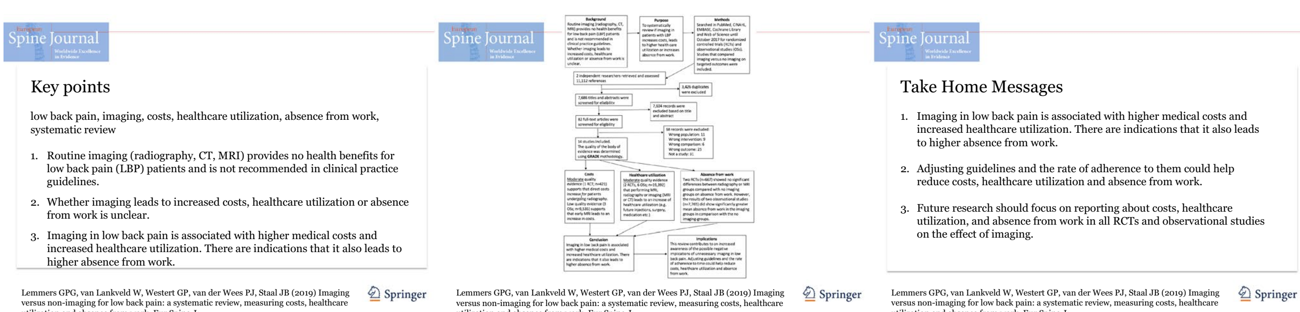
Abstract

Purpose Imaging (X-ray, CT and MRI) provides no health benefits for low back pain (LBP) patients and is not recommended in clinical practice guidelines. Whether imaging leads to increased costs, healthcare utilization or absence from work is unclear. Therefore, this study systematically reviews if imaging in patients with LBP leads to an increase in these outcomes.
Methods We searched PubMed, CINAHL, EMBASE, Cochrane Library and Web of Science until October 2017 for randomized controlled trials (RCTs) and observational studies (OSs), comparing imaging versus no imaging on targeted outcomes. Data extraction and risk of bias assessment was performed independently by two reviewers. The quality of the body of evidence was determined using GRADE methodology.
Results Moderate-quality evidence (1 RCT; $n=421$) supports that direct costs increase for patients undergoing X-ray. Low-quality evidence (3 OSs; $n=9535$) supports that early MRI may lead to an increase in costs. There is moderate-quality evidence (1 RCT, 2 OSs; $n=3897$) that performing MRI or imaging (MRI or CT) is associated with an increase in healthcare utilization (e.g., future injections, surgery, medication, etc.). There is low-quality evidence (5 OSs; $n=15{,}493$) that performing X-ray or MRI is associated with an increase in healthcare utilization. Moderate-quality evidence (2 RCTs; $n=667$) showed no significant differences between X-ray or MRI groups compared with non-imaging groups on absence from work. However, low-quality evidence (2 Oss; $n=7765$) did show significantly greater mean absence from work in the MRI groups in comparison with the non-imaging groups.
Conclusions Imaging in LBP may be associated with higher medical costs, increased healthcare utilization and more absence from work.

Graphical abstract

These slides can be retrieved under Electronic Supplementary Material.



Keywords Low back pain · Imaging · Costs · Healthcare utilization · Absence from work

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Extended author information available on the last page of the article

Introduction

Low back pain (LBP) is a dominant health issue with a lifetime prevalence between 50 and 85% and a point prevalence of 15–30% in modern countries [1, 2]. It also contributes to healthcare consumption and is the main determinant of years lived with disability [3, 4]. Worldwide costs of treating low back pain are very high and increasing over time [5, 6]. In the USA, direct and indirect healthcare costs are associated with the treatment of low back pain and add up to between 85 and 238 billion dollars every year [7, 8]. In the Netherlands, the indirect costs account for 88% of the total costs of low back pain [9]. These indirect costs consist mainly of costs associated with absence from work [10].

According to most guidelines for low back pain, objectives of conservative treatment are to reduce medication use, decrease pain and disability, and prevent surgery [11–13].

Lumbar imaging (X-ray, MRI or CT) is not recommended in these guidelines, except when malignant low back problems are suspected [14], although recent research has shown that empirical support for most red flags is lacking [15]. Adherence to guidelines may contribute to a reduction in costs and healthcare utilization [16], as overdiagnosis is a widespread problem [17]. The value of imaging in low back pain is questionable, as degenerative, congenital and postural abnormalities are prevalent in people without low back pain [18, 19]. These imaging findings are only vaguely correlated with symptoms from back pain and are not associated with future low back pain [20–23].

Despite this knowledge, in the USA imaging is performed in as much as 21.7–28.8% of the population with acute LBP in the first 4–6 weeks in the absence of an indication for such imaging techniques [24, 25]. X-ray was used in 12.0–32.2% of patients with LBP, magnetic resonance imaging (MRI) in 16.0–21.0% and computed tomography (CT) in 1.4–3.0% [26]. The use of CT and MRI in low back pain patients increased in the USA between 1999 (7.2%) and 2010 (11%), while the use of X-rays remained stable over that period [27]. Moreover, imaging does not seem to improve pain or function and negative consequences have been reported: It increases the number of spinal surgery, exposes patients to unnecessary harms and contributes to the increase in healthcare expenditures [25, 28–30].

It has been suggested that medical imaging without a clinical indication is prompted by the physician's need for reassurance of diagnosis, to specify an anatomical defect and to meet the expectations of patients or for financial incentives [31–33]. However, why and how general practitioners refer to imaging remains unclear [34, 35]. Referral to imaging increases costs. Reducing the amount of imaging is a possible way to save money [36]. Imaging in low back pain does not lead to better patient outcomes, but the effects on costs, healthcare utilization and absence from work have not been reviewed before [37, 29].

Therefore, the aim of this systematic review is to determine if imaging in patients without red flags suggesting serious low back pain is associated with increased costs, healthcare utilization or absence from work.

Methods

For this systematic review, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA statement) was used [38].

Data sources and searches

The following databases were searched: PubMed, CINAHL, EMBASE, Cochrane Library and Web of Science up to October 2017. "Appendix" shows the complete search strategy with the keywords used (MeSH, EMTREE and text words). All articles published in English were eligible. Two independent reviewers (GL and WvL) screened the results of the database search on title, abstract and keywords for the eligibility of the study population, intervention, comparison and outcome.

Study selection

Eligible studies included both randomized controlled trials (RCTs) and observational studies, comparing imaging (X-ray, CT and MRI) versus no imaging on targeted outcomes. The studies had to meet the following criteria: (1) They included patients with LBP with or without sciatica, (2) participants were older than 18 years of age, and (3) outcome measures contained costs, healthcare utilization or absence from work.

Studies were excluded when imaging was aimed at examining the presence of a specific pathology (e.g., spondyloarthropathies, oncological disease, systemic diseases, fractures or dislocation) in the presence of red flags symptoms.

Data extraction and quality assessment

Quality assessment of the selected studies was based on data extraction performed by two independent reviewers (GL and WvL). Data were extracted for design, study population, setting, intervention, follow-up period, costs, healthcare utilization and absence from work. Costs were expressed in USD or GBP. Healthcare utilization was expressed as relative risk, odds ratio or likelihood ratio for receiving future treatment.

The methodological quality of each randomized controlled trial was appraised using the Cochrane risk of bias tool [39].

The methodological quality of each included observational study was appraised using the National Institutes of Health (NIH) Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies [40]. The tool was designed to assist with the appraisal of internal validity (potential risk of measurement, selection, or information bias, or confounding) of cohort and cross-sectional studies and was, therefore, appropriate for this systematic review. Due to the expected scarceness of data regarding the targeted outcomes, poor or very poor studies were not excluded based on quality score.

The methodological quality of the included studies was independently assessed by both reviewers. Disagreements were discussed until consensus was reached. The reviewers were not blinded to the authors or the journal name.

Data synthesis and analysis

An overview for the randomized trials and a separate overview for all observational studies are presented summarizing number of studies, study design, type of imaging, number of patients, exclusion criteria, duration of low back pain, follow-up and primary outcome measures.

Conclusions concerning differences between imaging and non-imaging for costs, healthcare utilization and absence from work were formulated using the GRADE methodology separately for randomized controlled trials and observational studies [41–44].

The quality of the evidence from RCTs was rated as high and downgraded to moderate, low or very low evidence when one or more quality criteria were not met. Factors that may downgrade the quality of the evidence were limitations in study design and execution, inconsistency, indirectness of evidence and imprecision [39, 45, 46].

Evidence coming from observational studies was rated as low and upgraded if there was a large magnitude of an effect. When the relative risk was greater than 2, the magnitude of the effect was rated as large [39, 47].

Results

A total of 11,112 references were retrieved. After removing 3426 duplicates, 7686 titles and abstracts were screened for eligibility. Eighty-two full-text articles were retrieved. Finally, 14 studies were included for this review. The flowchart of reference selection is shown in Fig. 1.

The 14 included studies consisted of 6 RCTs and 8 observational studies. Characteristics of the RCTs are shown in Table 1, and quality assessment of the RCTs is shown in Table 2. Those of the observational studies are reported in Tables 3 and 4. Due to substantial differences in study design, outcome, follow-up and population, a meta-analysis or another form of subgroup analysis or data pooling could not be performed for any of the included studies. Results for the outcome measures are presented per type of imaging (i.e., MRI, X-ray, or CT), starting with the RCT's followed by the observational studies. Cochrane reporting recommendations were applied [48, 49].

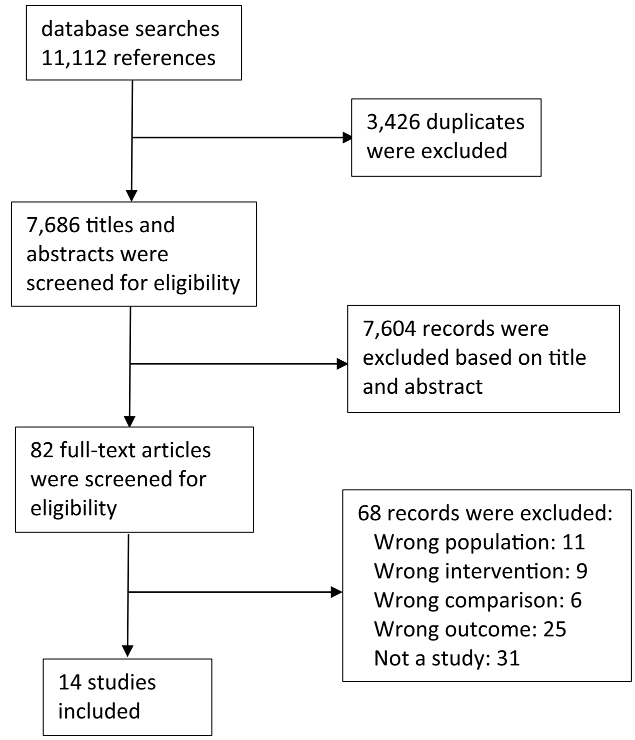

Fig. 1 Reference selection according to the reporting style of the PRISMA statement

Randomized controlled studies

MRI and costs

No studies were found that report on this possible relationship.

MRI and healthcare utilization

One study [50] ($n = 132$) compared two groups of physicians composing a treatment plan. One group was blinded to the results of the MRI. The other group was not blinded to the results. This study was conducted within a very specific population: patients who were diagnosed with radiculopathy and referred for epidural steroid injection. At one-month follow-up, 27% of the blinded group achieved a 20% or greater

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Table 1 Characteristics of randomized controlled trials

Author, year	Population	Intervention	Control	Outcome	Follow-up
Ash et al. [51]	246 patients with acute (3 weeks) LBP and/or radiculopathy (150 LBP and 96 radiculopathy patients) recruited from spine center, primary care units or emergency department Country: USA	MRI blinded	MRI unblinded (pt+ph)	No effect of blinding of the result of the MRI to the patient and health-care provider for the mean number of sick days	2, 4, 6 and 8 weeks 6, 12 and 24 months
Cohen et al. [50]	132 patients with lumbosacral radiculopathy referred for epidural steroid injections Country: USA	MRI blinded	MRI unblinded (ph)	Blinding of the physician leads to a significant increase in medication use at one-month follow-up and no significant difference at 3-month follow-up	1 and 3 months
Gilbert et al. [55]	782 participants who had been referred by their general practitioner to a consultant orthopedic specialist or neuro-surgeon because of symptomatic lumbar spine disorders Country: UK	Early imaging (MRI or CT)	Delayed, selective imaging	0–8 months: early imaging group had significantly more expenses on imaging and physiotherapy compared with the group of delayed, selective imaging. 9–24 months: early imaging group had significantly higher costs of hospital admissions Differences in other outcome measures, no significancy	8 and 24 months
Kendrick et al. [53]	421 patients with low back pain of a median duration of 10 weeks from 52 general practices Country: UK	Radiography of lumbar spine	No Rx/usual care	Relative risk of 1.62 ($p<0.01$) for the radiography group to have visited a doctor in the past 3 months compared with the control group. Other forms of healthcare utilization showed no significant differences between groups. No significant influence on taken time off work and median number of days off work	3 and 9 months
Kerry et al. [54]	139 patients consulting their general practitioner (GP) with low back pain at first presentation Country: UK	X-ray	No X-ray	Odds ratios of 1.6–2.4 for the radiography group to consult their GP subsequently for back pain and for referral to another healthcare provider at recruitment	6 weeks and 1 year
Miller et al. [52]	421 patients with low back pain of at least 6 weeks of duration from 52 general practices Country: UK	Radiography of lumbar spine	No Rx/usual care	Direct costs are higher ($p<0.001$) for the radiography group No significant difference was found for the indirect costs	3 and 9 months

Table 2 Assessment of randomized controlled trials

		Ash et al. [51]		Cohen et al. [50]		Gilbert et al. [55]		Kendrick et al. [53]		Kerry et al. [54]		Miller et al. [52]	
		GL	WvL	GL	WvL	GL	WvL	GL	WvL	GL	WvL	GL	WvL
1	Was the assignment of the intervention randomized to the patients?	+	+	+	+	+	+	+	+	+	+	+	+
2	The person who includes patients should not be aware of the randomization sequence. Was that the case here?	+	+	+	+	+	+	+	+	+	+	+	+
3	Were the patients and the practitioners blinded for the treatment?	+	?	+	+	?	–	–	–	–	–	?	?
4	Were the outcome assessors blinded for treatment?	+	?	+	+	?	–	?	–	?	?	?	?
5	Were the groups comparable at the beginning of the trial?	+	+	+	–	+	–	+	+	+	+	+	+
	If no: has this been corrected in the analyses?				+								
6	Is a complete follow-up available from a sufficient proportion of all included patients?	+	+	+	+	+	+	+	+	?	?	+	+
	If no: can selective loss to follow-up sufficiently be ruled out?												
7	Have all the included patients been analyzed in the group in which they were randomized?	+	+	+	+	+	+	+	+	+	+	+	+
8	Have the groups been treated equally, apart from the intervention?	+	+	+	+	+	?	+	+	+	+	+	+
9	Can selective publication of results sufficiently be ruled out?	+	+	+	+	+	+	+	+	+	+	+	+
10	Can unwanted influence of sponsors sufficiently be ruled out?	+	+	+	+	+	+	+	+	+	+	+	+

reduction in medication use versus 48% in the group where the physician was not blinded to the result of the MRI. This study did not report about other forms of costs.

This study provides moderate-quality evidence (imprecision) that blinding of the physician to the results of the MRI leads to a significantly smaller decrease in medication use by patients at one-month follow-up. This difference was no longer present at the 3-month follow-up.

MRI and absence from work

One study [51] ($n=246$) compared a group where patients and healthcare providers were blinded to the result of the MRI with a non-blinded group. There were no significant differences in the mean number of sick days measured at 6 weeks and 1 year.

There is moderate-quality evidence (imprecision) that there is probably no difference in the mean number of sick days between blinded and non-blinded groups to MRI results.

X-ray and costs

One study [52] ($n=421$) compared patients with low back pain that received X-ray to a group that received usual care without X-ray. Direct mean costs were $250 in the X-ray group compared to $180 in the usual care group without X-ray. Indirect mean costs were $748 in the X-ray group compared to $653 in the usual care group without X-ray. Observed differences were significant for direct mean costs, but not for the indirect costs.

There is moderate-quality evidence (serious limitations) that direct costs are probably higher for the X-ray group. There is probably no difference in the indirect costs.

X-ray and healthcare utilization

Two studies [53, 54] compared patient groups who received X-ray with control groups that did not receive X-ray.

The study of Kendrick et al. ($n=421$) reported a relative risk of 1.62 (CI 1.33–1.97) for the X-ray group to have visited a doctor in the past 3 months compared with the control group. Relative risks for other forms of healthcare utilization, like physiotherapy, osteopathy and medication use, showed no significant differences between groups [53].

Kerry et al. ($n=139$) reported no significant differences in the RCT section of the study between the X-ray group and the no X-ray group in any of the outcome measures. This study also contains an observational arm of which the results are shown in the results of the observational studies [54].

There is low-quality evidence (serious limitations and imprecision) from two studies that there may be no

Table 3 Characteristics of observational studies

Author, year	Population	Intervention	Control	Outcome	Follow-up
Aaronson et al. [59]	6094 patients with uncomplicated back pain visiting ED Country: USA	MRI	No MRI	Patients who had an MRI were more likely to be admitted to observation (74.2% vs. 10.8%; $p<0.0001$) and had a longer ED LOS (median 4.8 h vs. 2.7; $p<0.0001$)	1 week
Carey et al. [61]	872 general practice patients of which 551 (63%) reported that they had experienced lower back pain Country: Australia	Imaging (radiography, MRI or CT)	Non-imaging	Referred for imaging (radiography, MRI or CT) were prescribed medication (70%) compared with those not referred (39%, $p<0.001$)	12 months
Fritz et al. [60]	2893 patients with a new LBP-related primary care consultation Country: USA	Advanced imaging (MRI or CT)	Phys. ther.	Higher odds ratios (3.67–5.47) for the advanced imaging group (MRI or CT) for surgery, injections, spine surgeon visit, any spine specialist visit and emergency department visit compared with physical therapy group	12 months
Graves et al. [56]	1770 workers (age > 18) with work-related LBP using administrative claims Country: USA	No early MRI	Early MRI	Differences ($p<0.001$) between the nonadherent group and the guideline adherent group for receiving an injection (40.8% vs. 6.9%), surgery (19.9% vs. 2.5%) and mean visits of physiotherapy/osteopathy (18.4 vs. 6.8) and outpatient (12.2 vs. 4.3) higher costs ($p<0.001$) on all outcomes for the nonadherent group versus the adherent group. Mean total costs are $22,151 versus $6640	12 months
Kerry et al. [54]	419 patients consulting their general practitioner (GP) with low back pain at first presentation Country: UK	X-ray	No X-ray	Odds ratios of 1.6–2.4 for the radiography group to consult their GP subsequently for back pain and for referral to another healthcare provider at recruitment	6 weeks and 1 year
Webster and Cifuentes [25]	A total of 7210 LBP claims with paid lost time were identified by body part Country: USA	Early MRI	No MRI	Higher mean total medical costs for the early MRI group ($21,921) compared to the no-MRI group ($2779). Percentage to undergo surgery for no-MRI group was 0.8% versus 22.0% for the early MRI group. Mean first disability period of 134 versus 23 (no MRI) days	24 months
Webster et al. [57]	555 workers with acute, disabling, work-related low back pain (LBP) with and without radiculopathy Country: USA	Early MRI	No MRI	Total medical costs were lower in the no-MRI group. $4100 and $2306 for radiculopathy and nonspecific LBP in the no-MRI group versus $22,339 and $17,028 for radiculopathy and nonspecific LBP in the early MRI group; nonspecific LBP in the early MRI group had on average 165 sick days; no-MRI group only had 44.4 sick days on average	24 months
Webster et al. [58]	A total of 7210 LBP claims with paid lost time were identified by body part Country: USA	Early/timely MRI	No MRI	Relative risks of no-MRI group versus early or timely MRI group for receiving injections (25.17–32.70), EMG/NCV (35.13–54.89), advanced imaging (13.04–20.53) and surgery (6.48–33.80) ($p=0.001$)	3, 6, 9, and 12 months

Table 4 Assessment of observational studies

1 Was the research question or objective in this paper clearly stated?

2 Was the study population clearly specified and defined?

3 Was the participation rate of eligible persons at least 50%?

4 Were all the subjects selected or recruited from the same or similar populations (including the same time period)?

Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?

5 Was a sample size justification, power description, or variance and effect estimates provided?

6 For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?

7 Was the time frame sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?

8 For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?

9 Were the exposure measures (independent variables) clearly defined, valid, reliable and implemented consistently across all study participants?

10 Was the exposure(s) assessed more than once over time?

11 Were the outcome measures (dependent variables) clearly defined, valid, reliable and implemented consistently across all study participants?

12 Were the outcome assessors blinded to the exposure status of participants?

13 Was loss to follow-up after baseline 20% or less?

14 Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?

Aaronson et al. [59]		Carey et al. [61]		Fritz et al. [60]		Graves et al. [56]		Kerry et al. [54]		Webster and Cifuentes [25]		Webster et al. [57]		Webster et al. [58]	
GL	WvL	GL	WvL	GL	WvL	GL	WvL	GL	WvL	GL	WvL	GL	WvL	GL	WvL
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NA	NA	NR	NR	–	–	–	–	–	–	NR	CD	–	–	+	+
NA	NA	NR	NR	NR	+	+	+	+	+	+	+	+	+	+	+
–	–	–	–	CD	CD	+	+	–	–	+	+	+	+	+	+

association between performing X-ray and the amount of healthcare utilization.

X-ray and absence from work

One study [53] ($n = 421$) showed that performing X-ray has no significant influence on taken time off work and the median number of days off work.

There is moderate-quality evidence (serious limitations) that there is probably no influence of performing X-ray on absence from work.

Imaging studies (MRI or CT) and costs

One study [55] ($n = 782$) compared early imaging with delayed, selective imaging.

In the period of 0–8 months, the early imaging group had significantly more mean expenses on imaging ($139.95) and physiotherapy ($57.45), compared with the group of delayed, selective imaging (resp. $44.79 and $41.44). In the period of 9–24 months, the early imaging group had significantly higher mean costs of hospital admissions ($100.13) compared with the group of delayed, selective imaging ($62.79). Outcome measures (outpatient consultations, surgery, injections, back support/corset/brace, GP consultations, prescription medicines, nonprescription medicines and special tests) showed differences, but were not statistically significant.

There is very low-quality evidence (very serious limitations and inconsistency) to support that we are uncertain that imaging can lead to higher costs.

Imaging studies (MRI or CT) and healthcare utilization

No studies were found that report on this possible relationship.

Imaging (X-ray, MRI or CT) and absence from work

No studies were found that report on this possible relationship.

Observational studies

MRI and costs

Three studies [56, 25, 57] compared early MRI versus no MRI in low back pain patients.

Webster and Cifuentes [25] ($n=7210$) found significantly higher mean total medical costs for the early MRI group ($21,921) compared to the no-MRI group ($2779) [25].

The study of Webster et al. [57] ($n=555$) showed that total medical costs were significantly lower in the no-MRI group compared to the early MRI group. $4100 and $2306 for radiculopathy and nonspecific LBP in the no-MRI group versus $22,339 and $17,028 for radiculopathy and nonspecific LBP in the early MRI group [57].

Graves et al. ($n=1770$) report significantly higher costs (outpatient services, inpatient services, non-medical and disability compensation) for the early MRI group versus the no-MRI group. Mean total costs were $22,151 versus $6640 [56].

There is low-quality evidence that early MRI may lead to an increase in costs.

MRI and healthcare utilization

Four studies [25, 56, 58, 59] compared patients with low back pain who received MRI, with patients who did not receive MRI.

Webster and Cifuentes [25] revealed that the percentage to undergo surgery for the no-MRI group was 0.8% versus 22.0% for the early MRI group [25]. This difference was significant.

Graves et al. reported significant differences between the early MRI group and the no-MRI group for receiving an injection (40.8% versus 6.9%), surgery (19.9% vs. 2.5%) and mean visits of physiotherapy/osteopathy (18.4 vs. 6.8) and outpatient (12.2 vs. 4.3) at 12 months. The number of mean visits chiropractic did not differ between groups [56].

Webster et al. [58] revealed relative risks for the early or timely MRI group versus the no-MRI group for receiving injections (25.17–32.70), EMG/NCV (35.13–54.89), advanced imaging (13.04–20.53) and surgery (6.48–33.80) at 6 months. Results were displayed in a range, because groups were divided into more or less severe, and into early or timely MRI [58].

Aaronson et al. found with univariate analysis that patients who had an MRI were significantly more likely to be admitted to observation (74.2% vs. 10.8%) and had a longer emergency department length of stay (median 4.8 h vs. 2.7) [59].

Overall, there is low-quality evidence (large magnitude of an effect and indirectness of evidence) that receiving an early MRI may lead to an increase in healthcare utilization.

MRI and absence from work

Two studies [25, 57] compared early MRI versus no MRI in low back pain patients.

Webster and Cifuentes [25] reported a mean first absence from work period of 133.6 (CI 120.5–146.7) days for the early MRI group versus 22.9 (CI 19.5–26.2) days for the no-MRI group [25].

Webster et al. [57] reported a significantly longer length of mean first absence from work period for the early MRI group, regardless of radiculopathy. Patients with nonspecific LBP in the early MRI group had on average 165 (CI 128.5–201.5) sick days, where the no-MRI group only had 44.4 (CI 37.5–51.4) sick days on average. The rate of absence of work was 72% lower in no-MRI groups for the radiculopathy cases and 68% lower for the patients with nonspecific LBP cases [57].

Low-quality evidence supports that patients with low back pain who receive early MRI probably have a longer mean first absence from work period compared to the no-MRI group. There is low-quality evidence that patients who receive early MRI may have a higher rate of absence from work compared to the no-MRI group.

X-ray and costs

No studies were found that report on this possible relationship.

X-ray and healthcare utilization

One study [54] ($n=419$) compared a patient group who received X-ray with a group that did not receive X-ray.

In the observational arm of their study, Kerry et al. reported odds ratios of 1.6–2.4 for the X-ray group to consult their GP subsequently for back pain (within 6 weeks: OR 2.1; CI 1.2–3.5, 6 weeks to 1 year: OR 1.6; CI 0.95–2.7) and for referral to another healthcare provider at recruitment (OR 1.8; CI 1.0–3.2), within 6 weeks (OR 2.4; CI 1.4–3.9) and in the period from 6 weeks to 1 year (OR 1.9; CI 1.2–3.2).

There is low-quality evidence that performing X-ray for patients with low back pain may lead to an increase in healthcare utilization.

X-ray and absence from work

No studies were found that report on this possible relationship.

Imaging studies (X-ray, MRI or CT) and costs

No studies were found that report on this possible relationship.

Imaging (X-ray, MRI or CT) and healthcare utilization

Two studies [60, 61] compared groups who received imaging versus groups that did not.

The study of Fritz et al. showed higher odds ratios for the advanced imaging group (MRI or CT) for surgery (OR 5.47; CI 2.22–13.49), injections (OR 3.67; CI 2.20–6.10), spine surgeon visit (OR 4.01; CI 2.26–7.11), any spine specialist visit (OR 4.58; CI 2.95–7.11) and emergency department visit (OR 3.82; CI 1.05–13.90), compared with the group that received physical therapy [60].

Carey et al. report a significantly larger proportion of those referred for imaging (X-ray, MRI or CT) were prescribed medication (70%) compared with those who were not referred (39%, $p<0.001$) [61].

There is moderate-quality evidence (large magnitude of an effect) that imaging probably leads to an increase in healthcare utilization.

Imaging (X-ray, MRI or CT) and absence from work

No studies were found that report on this possible relationship.

Discussion

Statement of principal findings

This systematic review was performed to determine whether imaging in patients without red flags suggesting serious low back pain contributes to increased costs, healthcare utilization or absence from work.

This was the first study that systematically reports about differences in costs, healthcare utilization and absence from work, while comparing imaging versus no imaging in low back pain.

Overall, imaging (X-ray, CT or MRI) in low back pain does lead to an increase in costs, healthcare utilization or absence from work.

The results of this review revealed that all studies reported higher mean costs in the imaging groups in comparison with the non-imaging groups. Except for the RCT section of the study of Kerry et al., the average amount of healthcare utilization in all studies was significantly higher in the group that received imaging for at least one criterion (e.g., medication, injections, surgery). There is conflicting evidence for the outcome measure “absence from work”. RCTs showed no significant differences between X-ray or MRI groups compared with non-imaging groups. However, the results of the observational studies did show significantly greater mean absence from work in the imaging groups in comparison with the non-imaging groups.

Strengths and limitations

A strength of this review is the sensitive search method. Because of the use of a wide variety of synonyms for patients, intervention, comparison and the three different outcome measures, the chances of missing relevant studies are low. Another strength of this study is the use of the GRADE methodology and a solid rating system for the included studies. Both RCTs and observational studies were included, which resulted in a broader overview of available information compared to including RCTs only. This broad overview resulted in a wide variety of information, due to the heterogeneity in design, population, type of imaging, type of control group, follow-up periods and outcome.

All stages of low back pain were included, and the study selection was not restricted to “acute,” “subacute” or “chronic” low back pain [62, 63]. All RCTs and observational studies had methodological shortcomings.

Comparison with other literature

Previous similar literature research, performed by Karel et al. and Chou et al., focused on pain and function as outcomes, when comparing imaging versus no imaging in patients with low back pain and musculoskeletal disorders in general [29, 37]. They found no significant differences between imaging and no imaging for any of the outcome measures. Therefore, in addition to the knowledge that imaging does not improve outcome in pain or function, there is a tendency that imaging in low back pain can lead to an increase in costs, healthcare utilization and absence from work.

Meaning of the study: possible mechanisms and implications for clinicians or policymakers

Appropriate imaging seems difficult for multiple reasons, resulting in both overuse and underuse of imaging for low back pain [64]. Guidelines recommend against use of imaging for people with low back pain [65, 13, 66, 67]. Despite these recommendations, imaging rates are high [68–70]. It is possible to decrease imaging rates, but results of implementation programs on changing guidelines vary [71–75]. For example, imaging rates did not decrease after the Choosing Wisely campaign [69], but policymaking can have a positive effect on costs and healthcare utilization [76].

This review contributes to an increased awareness of the possible negative implications of unnecessary imaging in low back pain. Low back pain without red flag symptoms is complex, and imaging does not provide accurate guidance to the most appropriate treatment options in this group of patients. Adjusting guidelines and the rate of adherence to them could help reduce costs, healthcare utilization and absence from work.

Future research

A suggestion for future research is to look at why rates and frequency of imaging are increasing. The answers to this question might help us identify why imaging is performed and how to reverse this trend.

Another suggestion is to develop standardized guidelines reporting about costs, healthcare utilization and absence from work to be included in all RCTs and observational studies on the effect of imaging. These effects are often not described [17]. Previous research, especially in low back pain and imaging studies, had limited attention for these effects.

Conclusion

This study concludes that imaging in patients with low back pain does increase costs and healthcare utilization. There are indications that it also leads to higher absence from work. This is unwarranted for both patients and society since we know that imaging in low back pain has no health benefit.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest

Appendix: search strategy

#1 ((“Low Back pain”[mesh] OR “Diskectomy”[mesh] OR “Spinal diseases”[mesh] OR “back injuries”[mesh] OR “spinal fusion”[mesh] OR “sciatica”[mesh] OR “Sciatic Neuropathy”[mesh] OR backpain*[tiab] OR lumbar pain*[tiab] OR lumbar back pain*[tiab] OR lumbar backach*[tiab] OR lumbar spine pain*[tiab] OR lbp[tiab] OR sacral pain*[tiab] OR dorsalgia[tiab] OR backach*[tiab] OR back ach*[tiab] OR back pain*[tiab] OR radicular pain*[tiab] OR herniated dis*[tiab] OR slipped dis*[tiab] OR Lumbago*[tiab] OR back disorder*[tiab] OR back injur*[tiab] OR spinal fusion*[tiab] OR postlaminectomy*[tiab] OR post laminectomy*[tiab] OR arachnoiditis[tiab] OR failed back*[tiab] OR spondylit*[tiab] OR spondylosis[tiab] OR sciatic*[tiab] OR discitis[tiab] OR Radicular syndrom*[tiab] OR Radicular pain*[tiab] OR Spondylolisthes*[tiab] OR scoliosis[tiab] OR spinal stenosis[tiab] OR root stenosis[tiab] OR spine stenosis[tiab] OR degeneration dis*[tiab] OR degenerative dis*[tiab] OR displaced dis*[tiab] OR Disc problem*[tiab] OR disk problem*[tiab] OR back disab*[tiab] OR Piriformis Syndrome[tiab]) OR ((“pain”[mesh] OR “Pain Measurement”[Mesh] OR “Hernia”[mesh] OR pain[tiab] or ache*[tiab] OR aching*[tiab] OR Physical Suffering*[tiab] OR hernia*[tiab] OR Analges*[tiab] OR Nociception*[tiab]) AND (“Spine”[mesh] OR “back”[mesh] OR “spinal nerves”[mesh] OR “Intervertebral Disc”[mesh] OR spine*[tiab] OR spinal[tiab] OR Intervertebral Disk*[tiab] OR Lumbar Vertebra*[tiab] OR sacrum*[tiab] OR Cauda Equina*[tiab] OR facet joint*[tiab] OR coccyx[tiab] OR coccydynia[tiab] OR Ventral Root*[tiab] OR Dorsal Root*[tiab] OR anterior root*[tiab] OR posterior root*[tiab])))

#2 (“Magnetic Resonance Imaging”[mh] OR “magnetic resonance spectroscopy”[mh] OR magnetic resonance[tiab] OR NMR[tiab] OR MR[tiab] OR MRI[tiab] OR MRIs[tiab] OR mrs[tiab] OR MRSI[tiab] OR fMRI[tiab] OR fMRIs[tiab] OR fcmri[tiab] OR cmr[tiab] OR MRA[tiab] OR diffusion weighted[tiab] OR perfusion weighted[tiab] OR diffusion tensor[tiab] OR tractography[tiab] OR magnetization transfer*[tiab] OR zeugmatograph*[tiab] OR echo-planar[tiab] OR echoplanar[tiab] OR proton spin tomograph*[tiab] OR 1H-MR*[tiab] OR 1HMR*[tiab] OR H-MR*[tiab] OR HMR*[tiab] OR tesla[tiab] OR DWI[tiab] OR DTI[tiab] OR arterial spin labelling[tiab] OR arterial spin labeling[tiab] OR current density imag*[tiab] OR MP-RAGE[tiab] OR MPRAGE[tiab] OR turbo spin echo*[tiab] OR T1weighted[tiab] OR T2weighted[tiab]

OR T1-weighted[tiab] OR T2-weighted[tiab] OR t2 star[tiab] OR t2-map*[tiab] OR t2-value*[tiab] OR t2-relax*[tiab] OR t1-map*[tiab] OR t1-value*[tiab] OR t1-relax*[tiab] OR dgemric[tiab] OR ASL[tiab] OR imaging[tiab] OR "Radiography"[Mesh] OR radiograph*[tiab] OR Roentgenograph*[tiab] OR Tomography[mesh] OR tomograph*[tiab] OR "Diagnostic Imaging"[Mesh:NoExp] OR "Diagnostic Imaging"[SH] OR "Tomography, X-Ray Computed"[Mesh] OR ct[tiab] OR cts[tiab] OR cat scan*[tiab] OR catscan*[tiab] OR x ray*[tiab] OR xray*[tiab] OR scan*[tiab] OR photograph*[tiab] OR photo[tiab] OR photos[tiab] OR radiolog*[tiab] OR ACR[tiab])

#3 ("costs and cost analysis"[mesh] OR "cost of illness"[mesh] OR "Health Care Costs"[Mesh] OR "Insurance"[Mesh] OR "Referral and Consultation"[Mesh] OR Budget control*[tiab] OR Budget saving*[tiab] OR Care budget*[tiab] OR care expen*[tiab] OR Care expen*[tiab] OR Care fund*[tiab] OR Care spend*[tiab] OR champus[tiab] OR Claim analysis[tiab] OR Claim review*[tiab] OR Claims Analysis[tiab] OR Claims Review*[tiab] OR Coinsurance*[tiab] OR Competitive Health Plan*[tiab] OR Competitive Medical Plan*[tiab] OR control cost*[tiab] OR Cost allocat*[tiab] OR Cost analy*[tiab] OR Cost apportionment*[tiab] OR Cost benefit*[tiab] OR Cost compar*[tiab] OR Cost contain*[tiab] OR Cost control*[tiab] OR Cost effective*[tiab] OR Cost Efficien*[tiab] OR Cost evaluat*[tiab] OR Cost increase*[tiab] OR Cost manag*[tiab] OR Cost minimi*[tiab] OR Cost reduc*[tiab] OR Cost reduction[tiab] OR Cost saving*[tiab] OR Cost sharing[tiab] OR Cost shifting*[tiab] OR Costeffect*[tiab] OR Cost minimisation[tiab] OR Cost minimization[tiab] OR Deductible*[tiab] OR direct cost*[tiab] OR Economic evaluat*[tiab] OR Health Benefit Plan*[tiab] OR Health budget*[tiab] OR health care cost*[tiab] OR Health care saving*[tiab] OR health care spending[tiab] OR health care system*[tiab] OR health cost*[tiab] OR health expen*[tiab] OR health expenditure*[tiab] OR Health fund*[tiab] OR Health spend*[tiab] OR health spending*[tiab] OR Healthcare budget*[tiab] OR Healthcare cost*[tiab] OR healthcare expen*[tiab] OR Healthcare fund*[tiab] OR Healthcare savings[tiab] OR Healthcare spend*[tiab] OR healthcare spending*[tiab] OR healthcare system*[tiab] OR High cost*[tiab] OR High spend*[tiab] OR Increasing cost*[tiab] OR insuran*[tiab] OR Low cost*[tiab] OR managed car*[tiab] OR Medical budget*[tiab] OR Medical Care Cost*[tiab] OR medical cost*[tiab] OR Medical expen*[tiab] OR Medical fund*[tiab] OR medical saving*[tiab] OR Medical saving*[tiab] OR Medical spend*[tiab] OR medicare[tiab] OR Preferred provider*[tiab] OR Reducing cost*[tiab] OR Reimburs*[tiab] OR Rising cost*[tiab] OR Saving cost*[tiab] OR societal cost*[tiab] OR Third-Party Pay*[tiab] OR Treatment Cost*[tiab] OR Usage reduction*[tiab] OR Value Based Purchas*[tiab] OR Worker Compensation*[tiab] OR Worker s compensation*[tiab] OR Workers compensation*[tiab])

#4 ("Health Services Misuse"[Mesh] OR appropriateness criteria[tiab] OR overus*[tiab] OR over us*[tiab] OR overutili*[tiab] OR over utili*[tiab] OR misuse*[tiab] OR mis use[tiab] OR Unnecessary Surgery[tiab] OR Unnecessary procedur*[tiab] OR Unnecessary treat*[tiab] OR Unnecessary medic*[tiab] OR Overdiagno*[tiab] OR Over diagno*[tiab] OR Overmedication*[tiab] OR Over medication*[tiab] OR Misdiagnosi*[tiab] OR Mis diagnosi*[tiab] OR Unwanted Medical Car*[tiab] OR Overtreat*[tiab] OR over treat*[tiab] OR inappropriate[tiab] OR Justif*[tiab])

#5 ("absenteeism"[mesh] OR "Sick leave"[mesh] OR "Return to work"[mesh] OR work absen*[tiab] OR work disabilit* OR absenteeism[tiab] OR sick leav*[tiab] OR sick day*[tiab] OR sickness absen*[tiab] OR disability leav*[tiab] OR Illness Day*[tiab] OR absenteeism[tiab] OR absentism[tiab] or return to work[tiab] OR returning to work[tiab] OR absence from work*[tiab] OR away from work[tiab] OR employee performance[tiab] OR job performance[tiab] OR lost work day*[tiab] OR lost work*[tiab] OR missed work*[tiab] OR missing work[tiab] OR presenteeism[tiab] OR work ability[tiab] OR work attend*[tiab] OR work day*[tiab] OR work impairment*[tiab] OR workday*[tiab] OR work performance*[tiab] OR work productivity*[tiab] OR work loss*[tiab])

#6 #3 OR #4 OR #5

#7 #1 AND #2 AND #6

#8 Routine diagnostic imaging[tiab] OR Unnecessary scan*[tiab] OR Unnecessary mri*[tiab] OR Unnecessary radiograph*[tiab] OR Unnecessary imag*[tiab] OR Unnecessary x ray* OR acr appropriateness criteria*[tiab] OR choosing wisely[tiab] OR Mri utiliz*[tiab] OR MRI use[tiab] OR MRI usage[tiab] OR CT utiliz*[tiab] OR CT use[tiab] OR CT usage[tiab] OR image utiliz*[tiab] OR image use[tiab] OR scan utiliz*[tiab] OR scan use[tiab] OR scan usage[tiab] OR x ray utiliz*[tiab] OR x ray use[tiab] OR x ray usage[tiab] OR radiography use[tiab] OR radiography utiliz*[tiab] OR Early mri*[tiab] OR early x ray*[tiab] OR early imag*[tiab] OR early radiograph*[tiab]

#9 #1 AND #8

#10 #7 OR #9

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