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Appropriateness of lumbar spine magnetic resonance imaging in Spain☆

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ABSTRACT

Objectives: To determine the minimum percentage of lumbar spine magnetic resonance imaging (LSMRI) which are inappropriately prescribed in routine practice.
Methods: LSMRI performed prospectively on 602 patients in 12 Radiology Services across 6 regions in Spain, were classified as "appropriate", "uncertain" or "inappropriate" based on the indication criteria established by the National Institute for Clinical Excellence, the American College of Physicians and Radiology, and current evidence-based clinical guidelines. Studies on patients reporting at least one "red flag" were classified as "appropriate". A logistic regression model was developed to identify factors associated with a higher likelihood of inappropriate LSMRI, including gender, reporting of referred pain, health care setting (private/public), and specialty of prescribing physician. Before performing the LSMRI, the radiologists also assessed the appropriateness of the prescription.
Results: Eighty-eight percent of LSMRI were appropriate, 1.3% uncertain and 10.6% inappropriate. The agreement of radiologists' assessment with this classification was substantial ($k = 0.62$). The odds that LSMRI prescriptions were inappropriate were higher for patients without referred pain [OR (CI 95%): 13.75 (6.72; 28.16)], seen in private practice [2.25 (1.20; 4.22)], by orthopedic surgeons, neurosurgeons or primary care physicians [2.50 (1.15; 5.56)].
Conclusion: Efficiency of LSMRI could be improved in routine practice, without worsening clinical outcomes.

☆ Spanish Back Pain Research Network Task Force on MRI appropriateness for LBP.

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1. Introduction

Common low back pain (LBP) is defined as pain between the costal margins and the inferior gluteal folds, which may be associated with pain referred down to the leg ("leg pain"), and is usually accompanied by painful limitation of movement. Diagnosing common LBP implies that the pain is not related to conditions such as fractures, spondylitis, direct trauma, or neoplastic, infectious, vascular, metabolic, or endocrine-related processes [1,2]. In industrialized countries, LBP is one of the main causes of health-related and social costs [1,2].

Lumbar spine magnetic resonance imaging (LSMRI) is recommended for LBP patients with "red flags" for systemic diseases [1–4], and when surgery is considered for patients presenting signs and symptoms of radicular compression. The latter applies when cauda equine syndrome is suspected, and in cases of radicular pain caused by disk herniation (when conservative treatment has failed for ≥6 weeks) or spinal stenosis (when conservative treatment has failed for ≥12 weeks) (Table 1) [1–5].

LSMRI is not recommended when there are no signs suggesting that the pain is caused by systemic diseases or radicular compression [1,2,4]. In these cases, any potential findings on LSMRI have shown to be irrelevant [1,2,4,6], and do not help to refine the diagnosis, improve the outcome, or predict patient evolution [1,2,4,6–10].

Cutting inappropriate use of diagnostic procedures improves the quality of health care and the appropriateness of treatment, reduces wastage of health resources, and protects patients from undue risks and inconveniences [8–10]. However, programs to reduce inappropriate use also require resources. Therefore, costs deriving from inappropriate use should be estimated before considering implementing programs to reduce it. However, the evidence on the rate of inappropriate use of LSMRI is sparse [8,11–13].

Some studies suggest that a proportion of LSMRI prescribed in Spain is inappropriate, but one was conducted in one specific hospital while the other in a small health area [12,13]. Therefore, their results may not be generalizable.

Therefore, the objectives of this study were to; (a) quantify the minimum percentage of inappropriate use of LSMRI in different settings, and (b) explore factors associated with a higher risk of inappropriateness.

2. Methods

2.1. Setting

This study was approved by the Institutional Review Boards of the 12 centers across 6 Spanish regions which participated. These included 8 hospitals working for the Spanish National Health Service (SNHS) – one belonging to a non for profit Foundation and 7 to the SNHS. The latter included four tertiary hospitals – two mutual insurance companies for occupational accidents and disease, and two private centers.

2.2. Subjects

The inclusion criterion was to have been referred to any of the participating radiology centers for LSMRI prescribed for low back pain and/or sciatica.

The exclusion criteria were: previous spine surgery, inability to read Spanish, and refusal to sign the informed written consent. Furthermore, since one sign or symptom suggesting an indication criteria for LSMRI was enough to consider the prescription as "appropriate", while all the indication criteria had to be ruled out for it to be considered as "inappropriate", patients who left any of the questions exploring the existence of the indication criteria unanswered, were excluded at the analysis phase except if they had answered "yes" to the question exploring any other criterion, in which case the prescription was considered as appropriate.

Previous studies suggested that the proportion of inappropriate use of LSMRI might be 33–66% [8]. Assuming that it would be 50% (±5%), establishing a confidence interval of 95% and anticipating that up to 50% of patients could be excluded, sample size was established at 578. This sample size included the 291 patients required to detect a difference in the inappropriate use across the public and private settings, assuming that these would be 40% in the former and 60% in the latter, with a type I error of 0.05 and a type II of 0.10.

2.3. Procedure

Between June and December 2011, participating radiologists at each radiology services recruited all the patients complying with the inclusion criteria consecutively, and gave them a questionnaire on gender and signs suggesting "red flags" [1–5], such as age (date of birth), or history of osteoporosis, cancer or inflammatory rheumatism. The full list is shown in Table 1. The questionnaire also inquired the existence and duration of sciatica (pain referred down to the leg), pain referred down to the leg which appears when walking and disappears when sitting (neurogenic claudication), loss of strength or sensitivity in the legs or the genital area, and loss of sphincter control (Table 1). The questionnaire required patients to answer "yes" or "no" to each question. The comprehensibility of the questionnaire was assessed in a pilot study conducted in one of the participating radiology services, with 20 patients without university level education, who were asked to request assistance from the research staff to identify vocabulary which was difficult to understand.

Before performing the LSMRI, radiologists indicated whether they considered the prescription "appropriate", "inappropriate" or "uncertain", based on each patient's responses to the questionnaire and a list of the indication criteria (Table 1). They also indicated the setting where the LSMRI had been prescribed (public or private – which included mutual insurance companies) and whether the referring clinician indicated the reason for referral.

After having performed the LSMRI, radiologists indicated the date of prescription, the date of performance, and the date the radiological report was issued, together with the findings: disk protrusion or hernia, spinal stenosis, signs of vertebral fracture or vertebral compression fracture, signs of systemic disease (infection, cancer, spinal neurological diseases, other), and other radiological findings which, according to the evidence available, are as common among healthy individuals as among low back pain patients, and should not change the clinical management of LBP(disk degeneration, disk high intensity zone, facet joint degeneration, vertebral endplate changes, spondylolisthesis – and degree –, spondylolysis, other) [1–4,6,7].

Finally, the radiologist substituted patient's name with a code and sent all data to a coordination office, where data were introduced into a database manually twice by two auxiliary research staff who worked separately, in order to double-check that data introduced into the database matched those in patients' and radiologists' forms.

2.4. Analysis

Statisticians classified the LSMRI as "appropriate", "inappropriate" and "uncertain" based on data provided by patients through their questionnaire, according to the criteria listed in Table 1. A simple "red flag" sufficed for statisticians to classify the LSMRI as "appropriate".

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Table 1
Criteria for classifying the prescription of a lumbar spine magnetic resonance as "appropriate", "uncertain" or "inappropriate".

Classification	Appropriate (red flags for systemic disease)	Appropriate (red flags for potential surgical indication)	Uncertain	Inappropriate
Criteria	One or more of the following criteria: • Age > 70 years Recent (<6 months) trauma (of any severity if >50 years) or major trauma (at any age) • History of osteoporosis • Use of steroids for ≥6 months, ≤12 months before the prescription • Fever of unknown origin • Pain not influenced by posture and movement • Surgery in the last 6 months • Venous puncture (e.g., intravenous catheter, intravenous drugs) in the 6 months prior to LSMRI prescription • Pain predominantly at night which improves with movement • History of inflammatory rheumatism (e.g., ankylosing spondilytis) • Immunosuppression or use of immunosuppresors History of cancer Unjustified loss of ≥10% body weight • Weakness or loss of sensitivity in the legs.	One or more of the following criteria: • Signs suggesting cauda equina syndrome (urgent prescription of LSMRI): loss of sphincter control, saddle anesthesia, sensory level, important or progressive paresia • Severe pain referred down to the leg for ≥6 weeks, despite conservative treatment (possible symptomatic disk protrusion/herniation or spinal stenosis) • Neurogenic claudication for ≥12 weeks, despite conservative treatment (possible symptomatic spinal stenosis).	All of the following criteria, in the absence of criteria for appropriate prescription: • Severe or very severe low back pain, for ≥2 years, despite conservative treatment, and • Spinal fusion is being considered because intense exercise programs are not applicable in the case of the patient.	None of the criteria for appropriate or uncertain prescription.

Criteria for classifying the appropriateness of LSMRI derive from US and European evidence-based clinical guidelines and from the recommendations issued by the National Institute for Clinical Excellence (NICE), the American College of Physicians and the American College of Radiologists [1–4]. These recommendations consider signs of cauda equina syndrome and sciatica for ≥6 weeks as indication criteria for LSMRI, in order to assess potential surgical indication [1,2,4]. In this study, neurogenic claudication during ≥3 months despite conservative treatment was also considered an appropriate reason for prescribing LSMRI, since it has shown to be an indication for elective surgery when MRI shows lumbar spinal stenosis at the corresponding level [5].

The Kappa index was used to analyze the agreement between the classification of appropriateness based on data provided by patients, and radiologists' assessment. Kappa values were categorized according to Landis and Koch criteria [14].

All LSMRIs prescribed by physicians working in the private setting (including mutual insurance companies) were classified as "private health care", irrespectively of whether LSMRIs were performed in public and private facilities.

Continuous variables were described by their medians and interquartile ranges. Categorical variables were compared using Pearson's χ^2 or Fisher's exact test.

A logistic regression model was developed to assess which factors were associated with a higher risk of inappropriate vs. appropriate LSMRI, excluding "uncertain" ones. Variables included in the model were: patient's gender, pain referred down to the leg (yes/no), setting of prescription (public vs. private practice), and specialty of the prescribing physician (orthopedic surgeon – reference category – primary care, neurosurgeon, other).

The degree of significance was set at 0.05. The Stata statistical package (version 11.0; Stata Corp., College Station, TX, USA) was used.

3. Results

Six hundred and thirty-one patients were included, and 29 were excluded because they had left at least one question unanswered and had not given "yes" answers to any of the other questions addressing the existence of indication criteria. The remaining 602 were included. Their median (IQR) age was 48 (39; 59) years, 311 (51.8%) were female, and 382 (63.9%) had pain referred down to the leg (Table 2).

The prescription was classified as appropriate in 530 cases (88.0%), uncertain in 8 (1.3%), and inappropriate in 64 (10.6%) (Table 2). Radiologists did not classify the appropriateness of 18 (2.9%) LSMRI. For the remaining 584 patients, the agreement between this classification and the radiologists' assessment of appropriateness was substantial ($k = 0.625$) (Table 3).

The clinicians did not indicate the reason for prescribing 39 (6.5%) of the 602 LSMRI. Among these 39, 35 (89.7%) were appropriate and 4 (10.3%) were inappropriate. There are no significant differences between these proportions and the ones among LSMRI for which the reason for prescribing was indicated.

The prescription was inappropriate in 33 out of the 192 MRI studies prescribed in private practice (17.2%), vs. 30 out of the 408 prescribed in public practice (7.4%) ($p = 0.001$), and in 52 out of the 216 patients without referred pain (24.1%), vs. 12 out of the 382 with referred pain (3.1%) ($p < 0.001$). Primary care physicians only prescribed 25 out of the 602 LSMRIs (4.2%), but the proportion of inappropriate prescriptions was higher among these LSMRIs (20.0%) than among those prescribed by other specialists ($p = 0.04$). Conversely, all of the 27 LSMRIs prescribed by neurosurgeons were appropriately prescribed to patients with red flags for potential surgical indication (Table 2).

The regression model showed that factors associated with a higher risk of inappropriate prescription were private practice [OR (CI 95%): 2.25 (1.20; 4.22)] and not reporting referred pain [13.75 (6.72; 28.16)]. Conversely, the risk smaller among LSMRIs prescribed by specialists other than orthopedic surgeons, neurosurgeons and primary care physicians [OR = 0.40 (0.18; 0.87)] (Table 4). The category "neurosurgeon" had to be eliminated due to collinearity problems.

Among the 602 patients, 530 (88.0%) showed ≥1 red flag (Table 2). Among the 383 LSMRIs appropriately prescribed due to red flags suggesting potential systemic diseases, the latter were confirmed in 66 patients (17.22%), including cancer in 15.1% of those with a history of cancer (Tables 2 and 5). Among the 486

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Table 2
Sample characteristics ($N = 602$).

Variable	N‡	N (%)
Age†	567	48 (39; 59)
Gender (female)*	601	311 (51.8)
Experiencing pain referred down to the leg (yes)	598	382 (63.9)
Setting of the radiology service*	601	
Public healthcare		438 (72.8)
Mutual insurance company		99 (16.5)
Private healthcare		64 (10.7)
Setting of the prescribing physician*	600	
Public healthcare		408 (68.0)
Mutual insurance company		124 (20.7)
Private healthcare		68 (11.3)
Specialty of the prescribing physician*	590	
Primary care		25 (4.2)
Orthopedic surgeon		377 (63.9)
Neurosurgeon		27 (4.6)
Other		161 (27.3)
Reason for prescription, indicated*	563	532 (94.5)
Days elapsed between prescription and performance of the LSMRI†	602	23 (6; 51)
Days elapsed between performance of the LSMRI and issuing report†	503	2 (1; 4)
Red flags*		
Trauma	599	80 (13.4)
History of osteoporosis	587	77 (13.1)
Unjustified loss of ≥10% of body weight	599	58 (9.7)
Fever of unknown origin	592	22 (3.7)
Inmunosuppression or use of inmunosuppresors	599	13 (2.2)
History of inflammatory rheumatism	583	43 (7.4)
Pain constant or predominantly at night, which improves with movement	592	202 (34.1)
History of cancer	602	93 (15.5)
History of cancer or venous puncture in the last 6 months	596	104 (17.5)
Drug addiction (delivered intravenously)	596	3 (0.5)
Corticosteroids for ≥6 months, in the last 12 months	593	55 (9.3)
Loss of strength or sensitivity in the legs	596	218 (36.6)
Sciatica for >6 weeks	598	382 (63.9)
Suspicion of cauda equina syndrome		
Serious paresia	594	277 (46.6)
Progressive paresia	590	195 (33.1)
Saddle hyposthesia/anesthesia	587	174 (29.6)
Possible loss of sphincter control	589	56 (9.5)
Neurogenic claudication ≥3 months	597	256 (42.9)
Existence of ≥1 red flag*	602	530 (88.0)
For systemic disease	586	383 (65.4)
For potential surgical indication	601	466 (77.5)
For both (systemic disease and potential surgical indication)		383 (65.4)
Radiologists' assessment of appropriateness of prescription*	584	
Appropriate		504 (86.3)
Uncertain		27 (4.6)
Inappropriate		53 (9.1)
Appropriateness of prescription* (based on compliance with indication criteria, using data provided by patients)		
Appropriate	602	530 (88.0)
Depending on the setting[a]	600	
Public healthcare		371 (70.1)
Private healthcare (includes mutual insurance companies)		158 (29.9)
Depending on the existence of sciatica[b]	526	
With sciatica		370 (70.3)
Without sciatica		156 (29.6)
Depending on the specialty of the prescribing physician	520	
Primary care		19 (3.9)
Orthopedic surgery		327 (62.9)
Neurosurgery		27 (5.2)
Other		147 (28.2)
Uncertain	602	8 (1.3)
Depending on the setting[a]	8	
Public healthcare		7 (87.5)
Private healthcare	8	1 (12.5)
Depending on the existence of sciatica[b]		
With sciatica	8	0 (0.0)
Without sciatica		8 (100.0)
Depending on the specialty of the prescribing physician[c]		
Primary care		1 (12.5)
Orthopedic surgery		4 (50.0)
Neurosurgery		0 (0.0)
Other		3 (37.5)
Inappropriate	602	64 (10.6)
Depending on the setting[a]	63	
Public healthcare		30 (47.6)
Private healthcare	64	33 (52.4)

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Table 2 (*Continued*)

Variable	N‡	N (%)
Depending on the existence of sciatica[b]		
With sciatica	62	12 (18.8)
Without sciatica		52 (81.2)
Depending on the specialty of the referring physician[c]		
Primary care		5 (8.1)
Orthopedic surgery		46 (74.2)
Neurosurgery		0 (0.0)
Other		11 (17.7)
Findings on the lumbar spine magnetic resonance imaging (LSMRI)*	602	
Disk protrusion/herniation		406 (67.4)
Spinal stenosis		76 (12.6)
Disk fissure (high intensity zone)		121 (20.0)
Disk or facet join degeneration		441 (73.3)
Vertebral endplate changes		157 (26.1)
Spondylolysis		19 (3.2)
Spondylolisthesis		
Grade I		37 (6.1)
Grade II		5 (0.1)
Grade III		0 (0.0)
Grade IV		0 (0.0)
Radiological signs of		
Infection		2 (0.3)
Cancer		25 (4.2)
Fracture or vertebral compression fracture		37 (6.2)
Inflammatory rheumatism (ie, ankylosing spondylitis)		3 (0.5)
Spine neurological diseases (ie, syringomyelia)		4 (0.7)
Other findings (hemangiomas, etc.)		15 (2.5)

[a] In private healthcare, the proportion of inappropriate and uncertain lumbar spine magnetic resonances (LSMRIs) is higher, and the proportion of appropriate LSMRIs is lower ($p < 0.001$).
[b] The proportion of inappropriate prescription is lower among patients with sciatica than among those without sciatica ($p < 0.001$).
[c] The proportion of inappropriate prescription is higher among primary care than other specialties ($p = 0.04$).
* *N*, absolute number (percentage).
† Median (P25; P75).
‡ Number of cases for which data is available.

Table 3
Agreement between of appropriateness or referral and radiologists' assessment.[a]

		Appropriateness			
		Appropriate	Uncertain	Inappropriate	Total
Radiologists' assessment[b]	Appropriate	486 **(94.9)**	4 (50.0)	14 (21.9)	504 (86.3)
	Uncertain	20 (3.9)	2 **(25.0)**	5 (7.8)	27 (4.6)
	Inappropriate	6 (1.2)	2 (25.0)	45 **(70.3)**	53 (9.1)
	Total	512 (100)	8 (100)	64 (100)	584 (100)

Bold indicates percentage of agreement for each category of appropriateness and radiologists' assessment.
[a] Appropriateness was assessed using patients' answers to a questionnaire on the existence of any of the indication criteria for prescribing a lumbar spine magnetic resonance (Table 1).
[b] *N*, absolute number (percentage).

LSMRIs appropriately prescribed to confirm an indication criterion for surgery, the latter was confirmed in 73.6% cases (343 patients; 273 for disk protrusion/herniation, 17 for lumbar spinal stenosis, and 53 for both reasons simultaneously).

Among the 72 patients who did not show any red flags for systemic diseases or surgical indication, LSMRI found disk protrusions or herniations in 46 (63.9%), spinal stenosis in 1 (1.4%), and other findings in 4 (sacroiliitis suggesting inflammatory rheumatic disease in 1, vertebral hemangioma in 1, epidural lipomatosis in 1, and uterine leiomyoma in the remaining one).

Among the 203 patients without red flags for systemic disease, LSMRI showed relevant findings in 6; the 4 previously described with no red flags of any kind, and 2 whom, having reported red flags for a potential surgical indication, showed a vertebral hemangioma (1 case) and a cauda equina meningioma (1 case) (Table 4).

Among the 135 patients without red flags for surgical indication, LSMRIs showed disk protrusions/herniations in 79 (58.5%) and spinal stenosis in 6 (4.4%).

The median (interquantile range) number of days elapsed between prescription and performance of LSMRI was 23 (6; 51); 36 (18; 57) in public health care and 5 (2; 10) in private care ($p < 0.001$). Two days (1; 4) was the time elapsed between performance of LSMRI and issuing of radiological report; 2 (1; 5) in public care and 1 (0; 4) in private care ($p = 0.004$).

Table 4
Variables associated with inappropriate prescription of lumbar spine magnetic resonances.

Variable	OR (CI 95%)	p
Prescription in private healthcare	2.25 (1.20; 4.22)	0.011
Gender (female)	0.89 (0.48; 1.64)	0.714
Not presenting sciatica	13.75 (6.72; 28.16)	<0.001
Specialty of the prescribing physician		
Orthopedic surgeon	Reference category	0.070
Primary care	3.31 (0.90; 12.14)	
Neurosurgery[a]	–	0.020
Other	0.40 (0.18; 0.87)	

[a] The category "Neurosurgery" could not be analyzed due to collinearity problems.

4. Discussion

These results reveal that 6.5% of LSMRI referrals do not disclose the reason for prescription, and that at least 11.9% of referrals are

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Table 5
Findings in the lumbar spine magnetic resonance imaging (LSMRI) prescribed to patients who presented and did not present red flags for systemic diseases (irrespectively of whether they presented red flags for potential surgical indication).

		Potentially pathological findings in LSMRI		
		Yes	No	Total
Red flags for systemic diseases[a]	Yes	66 (17.2)	317 (82.8)	383 (100)
	No	6[b] (3.0)	197 (97.0)	203 (100)
	Total	72	514	586

[a] *N*, absolute number (percentage).
[b] Vertebral hemangioma (2 cases), sacroiliitis suggesting inflammatory rheumatism (1), epidural lipomatosis epidural, uterine leiomyoma (1), and cauda equina meningioma (1).

either inappropriate or uncertain. The percentage of inappropriate prescription is higher in private healthcare (17.2%), and among low back pain patients without referred pain (27.8%) (Table 2). In fact, the factors associated with a higher risk of inappropriate prescription are private practice (OR = 2.25) and absence of referred pain (OR = 13.75) (Table 4). These results are generally consistent with previous studies [11–13].

A previous study in a primary care area in Spain showed that the proportion of inappropriate or uncertain LMRIs was 13.8%, which increased to 80% among patients without referred pain [13]. In the current study, the gross proportions are similar (11.9%), but the percentage for patients without referred pain is only 27.8%. Differences in objectives and methods can explain this variation. The current study focused on estimating the minimum proportion of inappropriate use: therefore, methods aimed to ensure that all LMRIs classified as "inappropriate" were actually so, at the expense of underestimating its percentage. For instance, patients with a history of spine surgery were excluded from this study, one single red flag was considered sufficient justification to classify a LSMRI as "appropriate", and patients who did not rule out all red flags were excluded from the study, unless they had one red flag making it possible to classify the LSMRI as "appropriate". Moreover, LMRIs in the public health setting were performed 36 days after having been prescribed, implying that the LMRIs prescribed after 10 days of referred pain, would have been classified as "appropriate" (since they would have been performed >45 days after pain started). Furthermore, since the severity of referred pain when LSMRI was performed was not measured; these LSMRI would have been considered as "appropriate" even if referred pain had disappeared before the procedure was performed. In fact, a study in Canada showed that only 26% of referrals to a neurosurgical department for sciatica were appropriate [15].

Methods in this study also implied considering LMRIs as "appropriate" despite a very weak clinical ground, such as those performed to all subjects aged ≥70 years without any others red flags. In fact, red flags have not been defined for identifying the patients in whom diagnostic tests are necessary, but to identify those in whom, taking into account their specific clinical history and results from physical examination, the physician should consider whether any additional diagnostic test may be indicated [1–4]. Red flags have been defined clinically, instead of epidemiologically, with the goal of being more sensitive than specific. In fact, the evidence on their specificity is weak [16,17], and although low back pain is due to a systemic disease in approximately 1% of the cases, over 80% of the patients show ≥1 red flag (Table 2) [17]. This has led to recommending of downgrading the intrinsic weight of individual red flags appearing in isolation, as opposed to the clinical suspicion raised by the identification of a cluster of red flags [1–4,16,17].

Most studies assessing the sensitivity of red flags for systemic diseases have been conducted in primary care [1–4,16,17] whereas in the current one over 95% LSMRI were prescribed in the specialized setting, including an oncologic hospital. This may explain that LSMRIs conducted in this study identified rare findings, such as cauda equina meningioma or epidural lipomatosis, and that the proportion of patients with ≥1 red flag (88.0%) was higher than in most previous studies (approximately 80%) [16–18].

Since vertebroplasty and kyphoplasty have not shown to be more effective than placebo for treating vertebral compression fractures [19], the two conditions for which early diagnosis using red flags can improve the prognosis to a greater extent are cancer and cauda equina syndrome [2,3,17]. Since false positives for diagnosing the latter are similar irrespectively of whether red flags are used or not [17], the main concern is that restricting LMRIs to patients with red flags for systemic conditions may allow a cancer patient to go by undetected [2–4,17]. Although this study was not designed to assess the sensitivity of the red flags and its sample size does not allow for it, it is reassuring that all cancer patients did present red flags, and that none of the patients without those red flags had cancer or any other life-threatening or urgent diseases. This is consistent with the notion that clinicians need not be concerned that limiting LMRIs to patients with red flags may delay the diagnosis of patients with serious diseases [2,3,8,17,18]. In fact, in this study, most findings on LMRIs of patients without red flags are of dubious clinical relevance (Table 5). This is also consistent with the notion that restricting LMRIs in specialized care to patients with red flags, would not imply any clinical prejudice and could save resources and avoid unnecessary risks [1–5,8,9].

Several reasons may account for the higher proportion of inappropriate prescriptions within private practice, as compared to public practice. Prescribing a LSMRI increases patients' satisfaction [20], probably due to the misguided but widespread belief that LMRIs are necessary to establish the cause of low back pain [1–6]. In private practice, physicians may pay more attention to patients' satisfaction and feel incentivized to comply with patients' wishes. Patients more interested in being prescribed a LSMRI may also feel more compelled to using private healthcare, where the waiting period is 7 times shorter. Defensive medicine can also be a greater source of concern in private healthcare, where clinicians and health organizations can also have incentives for prescribing more imaging tests, or for recommending early surgery in cases in which LSMRI is pre-requisite [1–5,20].

However, prescribing LSMRI in inappropriate cases leads to wastage of resources and can be clinically damaging [8,9,20]. The greater the number of inappropriate LMRIs, the greater the number of misdiagnosis with serious consequences [21], and the agreement among radiologists when interpreting LMRIs is, at best, only moderate irrespectively of the nomenclature used [22]. Moreover, undergoing a LSMRI when it is not indicated increases the risk of unnecessary surgery up to 400% [8]. Therefore, the greater the number of low back pain patients undergoing inappropriate LMRIs, the higher the number of patients operated unnecessarily. For instance, some surgical societies recommend spinal fusion for low back pain patients if LSMRI show vertebral endplate changes and other signs of disk degeneration [23], despite the fact that these findings appear on the LSMRI of virtually all subjects above a certain age [6,7], that they have shown to be clinically irrelevant [6,7], and that, for that indication, results from spinal fusion are similar to those from intense exercise [1].

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Moreover, LSMRI shows findings which are commonly seen in asymptomatic, healthy subjects, such as disk protrusion or hernia. Although these findings only suggest the convenience of considering surgery if they trigger severe symptoms which last for over a certain time despite conservative treatment [1,25–27], their identification modifies physicians attitude and may lead to unnecessary surgery and risks [2,8]. In fact, in the current study LMRIs showed disk herniations or spinal stenosis in 63% of the patients without criteria for considering surgery, in whom these findings could have led to unnecessary surgery, risks and costs [5,8,9,15,24].

Given that the mean cost of a LSMRI in Spain is 244€ [29], results from this study suggest that there is room to improve the efficiency of resources by decreasing the inappropriate use of LSMRI. With this objective, publishing guidelines has proven insufficient [26]. Conversely, in the context of shared decision making, patient education has shown to be effective for reducing unnecessary prescription of LSMRI and associated risks while maintaining patient satisfaction [20]. Clinical decision support tools have also shown to reduce inappropriate prescription [27]. Results from this study show that radiologists can validly assess the appropriateness of LSMRI prescription (Table 3), as long as they have access to patients' clinical features and a reminder of indication criteria. Therefore, it might be suitable to allow radiologists to request that referring clinicians provide them with the reasoning for requesting a LSMRI when it appears to not comply with the indication criteria. Programs for reducing inappropriate use could also be implemented. Another way to protect patients from some of the harm deriving from inappropriate LSMRI would for radiologists to stop reporting findings which are clinically irrelevant, or to include in their reports epidemiological data showing their clinical irrelevance [6,7,28].

This study has some weaknesses. Patients were asked whether they presented any red flags, and their answers were not checked against their clinical records. However, this is how patients usually provide information to physicians in routine practice, and it appears unlikely for a patient to forget having been diagnosed with conditions such as ankylosing spondylitis or cancer. The cross-sectional design of this study made it impossible to assess the appearance of systemic diseases among patients with red flags, or the variations in clinical management which inappropriate LSMRI implied. However, these were not the study objectives. Radiology services participating in this study were located in only 6 out of the 17 Spanish regions, and there are variations in the cost of LSMRI [25] and differences by healthcare provider [29]. Therefore, it is possible for the proportion of inappropriate use to vary across regions although it was assessed in accordance with recommendations for imaging procedures [30]. Because of the multicentric design of this study, sample size was slightly larger than planned, but this does not raise ethical problems since the study design was observational and did not imply any variations in patients' management.

In conclusion, this study suggests that at least 11.9% of the lumbar spine magnetic resonances prescribed in routine practice are not appropriate, and that this proportion increases to 17.2% in private care and to 27.8% among patients without pain referred down to the leg.

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