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REVIEW ARTICLE

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Factors influencing imaging clinical decision-making in low back pain management. A scoping review

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Abstract

Background: The use of diagnostic imaging in low back pain (LBP) management is often inappropriate, despite recommendations from clinical practice guidelines. There is a limited understanding of factors that influence the imaging clinical decision-making (CDM) process.

Aim: Explore the literature on factors influencing imaging CDM for people with LBP and consider how these findings could be used to reduce inappropriate use of imaging in LBP management.

Design: Scoping review.

Method: This review followed the Preferred Reporting Items for Systematic Review extension for scoping reviews. A digital search was conducted in Medline, the Cumulative Index of Nursing and Allied Health Literature, Scopus, and the Cochrane Central Register of Controlled Trials for eligible studies published between January 2010–2023. Data reporting influences on imaging CDM were extracted. Data were then analysed through an inductive process to group the influencing factors into categories.

Results: After screening, 35 studies (5 qualitative and 30 quantitative) were included in the review, which reported factors influencing imaging CDM. Three categories were developed: clinical features (such as red flags, pain, and neurological deficit), non-modifiable factors (such as age, sex, and ethnicity) and modifiable factors (such as beliefs about consequences and clinical practice). Most studies reported non-modifiable factors.

Conclusions: The results of this scoping review challenge the perception that imaging CDM is purely based on clinical history and objective findings. There is a complex interplay between clinical features, patient and clinician characteristics, beliefs, and environment. These findings should be considered when designing strategies to address inappropriate imaging behaviour.

KEYWORDS

clinical decision-making, clinician beliefs, diagnostic imaging, low back pain, patient beliefs

1 | INTRODUCTION

Low back pain (LBP) is the leading cause of disability worldwide, affecting 619 million people in 2020 (Ferreira et al., 2023). Clinical practice guidelines (CPG) for the management of LBP recommend conservative use of diagnostic imaging (Lin et al., 2020). Specifically, imaging is indicated when findings are likely to alter management, symptoms persist or deteriorate unexpectedly despite conservative care, or if serious underlying pathology is suspected (Lin et al., 2020). While persistent symptoms are common, most LBP episodes improve within 6 weeks (Wallwork et al., 2024) and are not attributed to serious underlying pathologies (Galliker et al., 2019; Henschke et al., 2009, 2013; Williams et al., 2023). However, approximately one in three imaging referrals for LBP are inappropriate across clinical settings (Downie et al., 2020; Jenkins et al., 2018; Müskens et al., 2022). In this review, inappropriate imaging is defined as imaging for LBP which does not adhere to CPG's.

Inappropriate imaging has considerable economic and clinical implications. A systematic review by Kjelle et al. (2024) estimated that the worldwide cost of inappropriate imaging exceeded billions of dollars (USD 2022) between 2012 and 2022, with inappropriate imaging for LBP accounting for approximately 4 billion dollars. Furthermore, two recent systematic reviews have shown that inappropriate overuse of imaging in LBP management results in greater cost for patients from healthcare appointment and treatment fees (Lemmers et al., 2019) and prolonged absenteeism from work (Shraim et al., 2021). Inappropriate imaging was also associated with higher rates of epidural steroid injections, medication, and surgical intervention (Lemmers et al., 2019). Significant efforts have been made to understand the challenges clinicians face in following LBP guidelines (Hall et al., 2019) and how to improve guideline adherence (Belavy et al., 2022; Kjelle et al., 2021). However, interventions to reduce inappropriate imaging have shown variable success (Belavy et al., 2022; Kjelle et al., 2021) and imaging rates have continued to increase (Downie et al., 2020). In 2020, the 2018 Lancet LBP series was updated, reinforcing the call to reduce low value care in LBP management (Buchbinder et al., 2020). The series highlighted the considerable disparity between evidence for the use of imaging and clinical practice across the globe and called for individual, policy, legislative and system level change.

Makanjee et al. (2018) conducted an exploratory qualitative study and reported that the decision to refer for imaging is informed by gathering information from the patient's clinical history, which is then clarified through an objective examination. These findings are then interpreted to decide whether imaging is required at the clinician's discretion (Makanjee et al., 2018). However, non-clinical influences related to the clinician, patient and environment are known to influence clinical decision-making (CDM) (Hajjaj et al., 2010).

The aim of this scoping review is to examine the literature on factors that influence imaging CDM in LBP management and consider how these findings could be used to reduce inappropriate use of imaging.

2 | METHODS

2.1 | Protocol

This scoping review followed the methodological recommendations described by Levac et al. (2010) and Arksey and O'Malley (2005), which involved the following stages: (1) identifying the research question, (2) identifying relevant studies, (3) study selection, (4) charting the data and (5) collating, summarising, and reporting the results. The review was conducted in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis extension for Scoping Reviews (PRISMA-ScR) (Tricco et al., 2018).

2.2 | Search strategy

A computerised search was conducted using MEDLINE, the Cumulative Index of Nursing and Allied Health Literature Complete, Scopus, and the Cochrane Central Register of Controlled Trials library in February 2023. Three authors formulated the search strategy (see Appendix A). The strategy was refined iteratively, with regular group meetings to screen the search. The search was limited to peer-reviewed studies involving human participants published between January 2010 and January 2023 to provide an up-to-date depiction of clinical practice. The search was also limited to studies published in English due to limited resources.

2.3 | Eligibility criteria

Inclusion criteria were healthcare clinicians referring to patients for imaging. Imaging included: X-ray, Computed Tomography, Scintigraphy or Magnetic Resonance Imaging. Patients referred for imaging could be of any age and with LBP of any duration. The included study needed to explore the CDM factors or process factors that influenced referral for imaging.

Exclusion criteria were studies of participants with an existing diagnosis of neoplasm (as this necessitates regular screening); or who were regular wheelchair users (due to the specific healthcare needs of this population); or who were elite athletes (this population is frequently over-imaged based on contractual obligations to treat even minor injuries). Studies were ineligible if they were related to non-diagnostic or pre-surgical imaging, or if they studied photography or videography. Review studies and study protocols were excluded.

2.4 | Selection of sources of evidence

All studies were exported into bibliographic management software (Endnote 20.6) and duplicates were removed. Titles were then screened with a high threshold for exclusion. After reaching a consensus on eligibility criteria, three reviewers independently

screened one-third of the remaining abstracts against eligibility criteria for full-text review. The remaining full-texts were retrieved, and one-third each were screened by the same reviewers, with discrepancies resolved via regular discussion. Hand searches of websites and the reference lists of included studies were completed to check if eligible studies had been missed.

2.5 | Data charting process

The wider research team met to develop the data extraction tool based on the data we anticipated. The primary reviewer selected one study to test the data extraction tool and shared it with the team. Once the team reached a consensus, the primary author applied the process to the remaining studies. The development of this tool was an iterative process, which was in response to the diversity of CDM influencing factors documented in the literature.

2.6 | Data items (outcomes)

We collected data on study characteristics, such as study design, participants, and the clinical and geographical setting. Key data, reported to have an influence on imaging CDM were then extracted.

2.7 | Synthesis of results

The wider team collaborated using an inductive process to synthesise the data. Initially, like-data were grouped thematically, (such as age, sex, pain, or clinical history), distinguishing between clinician, patient and environmental factors. Data were then grouped into key categories and subcategories. Content detail was then explored narratively.

3 | RESULTS

3.1 | Selection of sources of evidence

An electronic search of databases and registers retrieved 3981 studies. Additionally, 12 studies were retrieved through hand searches of reference lists and four from journal websites. After duplicates had been removed, 2926 studies remained, which were then screened by title. The remaining 100 studies were screened by abstract leaving 81 studies. One full text could not be retrieved. The full text of 80 studies was then screened. A total of 35 eligible studies were included in this review (see Figure 1).

3.2 | Characteristics of sources of evidence

Table 1 provides an overview of the characteristics of the included studies. The complete set of study characteristic data can be found in Appendix B. The majority (n = 33; 94%) of the included studies were completed in high-income economies, and two were from lower-middle income economies (n = 2; 6%).

3.3 | Results of individual sources of evidence

Tables 2 to 4 summarise the publications which report clinical features and non-modifiable and modifiable factors which report influences on imaging CDM.

3.4 | Synthesis of results

The groups of like-data were categorised into clinical features, non-modifiable and modifiable factors. This categorisation acknowledges that clinical features, while central to the CDM process and subject to change over time, are generally static during the imaging CDM process. Similarly, patient and clinician characteristics such as age, sex, or socioeconomic status are static during this process and were considered non-modifiable. Subsequently, patient and clinician beliefs were deemed the primary modifiable factors influencing imaging CDM as they are measurable, plausibly contribute to the imaging CDM process and can be changed (Alwan et al., 2024). The data detailing factors influencing imaging CDM were then narratively summarised.

3.4.1 | Clinical features

Ten (n = 1) studies reported clinical features that influence imaging CDM (Barnett et al., 2020; Ely et al., 2018; Ferreira et al., 2019; Graves et al., 2012; Kohns et al., 2018; Loy et al., 2019; Peurois et al., 2022; Piccoliori et al., 2013; Schlemmer et al., 2015; Urrutia et al., 2020) (Table 2).

Clinical features were divided into seven subcategories: red flags (n = 4; 40%), pain (n = 6; 60%), neurological deficit (n = 3; 30%), cognitive and disability metrics (n = 3; 30%), presentation (n = 1; 10%) and injury severity (n = 1; 10%) (Table 2).

3.4.2 | Non-modifiable factors

Twenty-six studies (n = 26) reported non-modifiable factors that influence imaging CDM, which were divided into patient characteristics, clinician characteristics and the clinical setting (Table 3).

Eighteen studies (n = 18) reported that patient characteristics influence imaging CDM (Barnett et al., 2020; Bouck et al., 2019; Doll et al., 2022; Ely et al., 2018; Ferreira et al., 2019; Friedman et al., 2010; Gidwani et al., 2016; Graves et al., 2012; Hong et al., 2017; Kohns et al., 2018; McCaughey et al., 2016; Pakpoor et al., 2020; Peurois et al., 2022; Schlemmer et al., 2015; Tan et al., 2016; Traeger et al., 2021; Urrutia et al., 2020; Zargar et al., 2014). Patient characteristics were divided into five subcategories: age (n = 14; 78%), sex (n = 7; 39%), ethnicity (n = 5; 28%),

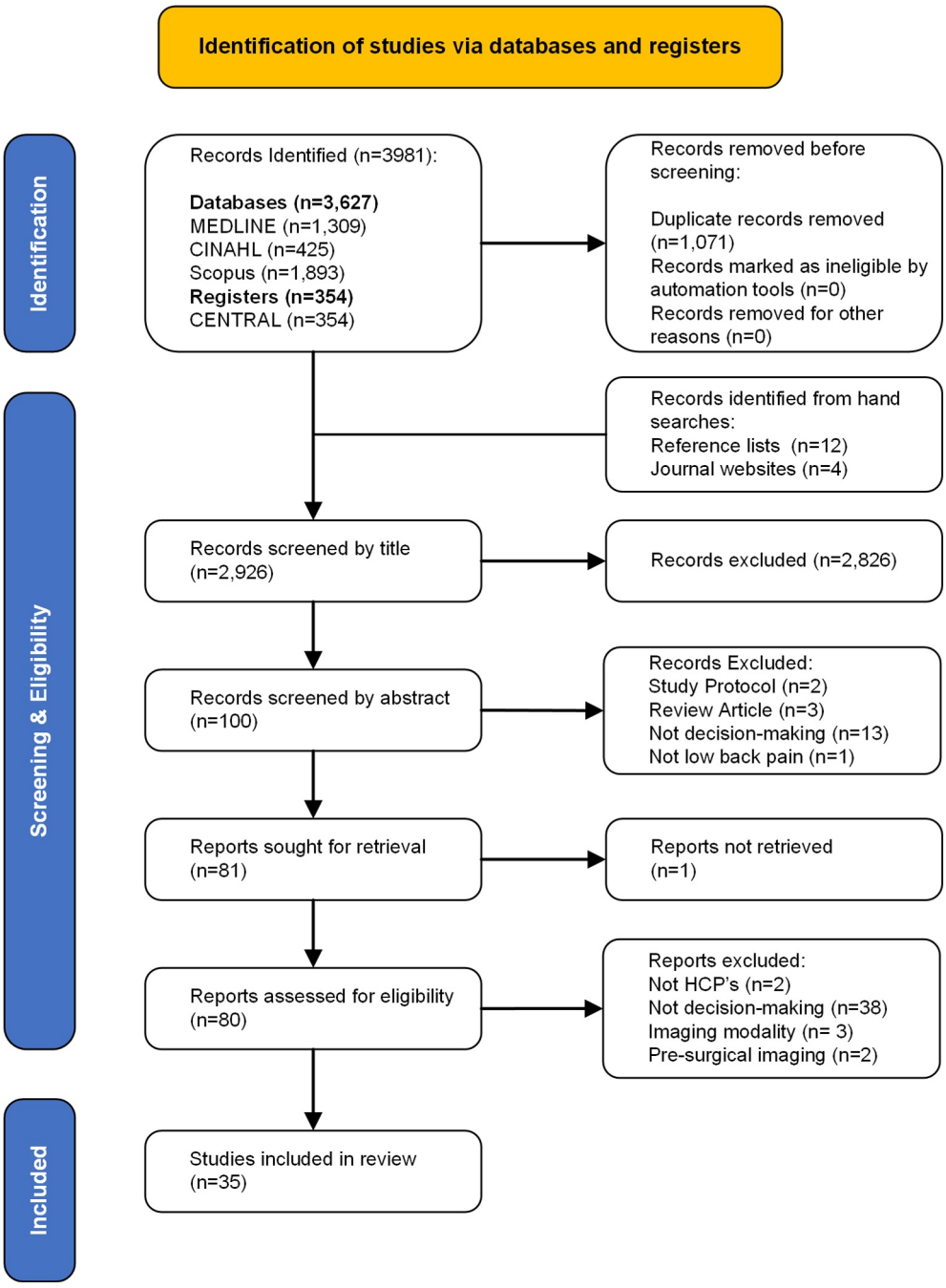

FIGURE 1 PRISMA-ScR flow chart (Page et al., 2021).

socioeconomic factors (n = 8; 44%), and clinical history (n = 8; 44%) (Table 3).

Fifteen studies (n = 15) reported that clinician characteristics influence imaging CDM (Arishy et al., 2022; Barnett et al., 2020; Bouck et al., 2019; Bussières et al., 2013; de Zoete et al., 2022; Dietrich et al., 2018; Ganesh et al., 2022; Gidwani et al., 2016; Graves et al., 2012; Hong et al., 2017; Le et al., 2018; Learman et al., 2014; Sears et al., 2016; Tan et al., 2016; Zargar et al., 2014). Clinician characteristics were divided into six subcategories: age (n = 1; 7%) sex (n = 1; 7%), experience (years) (n = 5; 33%), education (n = 4; 27%), role (n = 8; 53%) and clinical practice (n = 6; 40%) (Table 3).

Nine studies (n = 9) reported clinical setting factors that influence imaging CDM (Barnett et al., 2020; Bussières et al., 2013; de Zoete et al., 2022; Gidwani et al., 2016; Le et al., 2018; Learman et al., 2014; Pakpoor et al., 2020; Schlemmer et al., 2015; Zargar et al., 2014). The clinical setting was divided into three subcategories: geographical (n = 3; 33%), clinic characteristics (n = 7; 78%) and service structure (n = 1; 11%) (Table 3).

TABLE 1 Summary of included study characteristics.

Characteristics	*n* (%)
Design	
Qualitative	5 (14)
Focus groups	2 (6)
Semi-structured interviews	2 (6)
Combination	1 (3)
Quantitative	30 (86)
Prospective patient data analysis	2 (6)
Retrospective patient data analysis	21 (60)
Survey	5 (14)
Vignette	2 (6)
Region	
Asia	4 (11)
Europe	6 (17)
North America	20 (57)
South America	1 (3)
Oceania	4 (11)
Setting	
Emergency department	8 (23)
General practice/primary care	7 (20)
Health system database	8 (23)
Miscellaneous	8 (23)
Multi-site	2 (6)
Not reported	1 (3)
Tertiary care pain clinic	1 (3)
Participants	
Patients	15 (43)
Clinicians	12 (34)
Both	8 (23)
Clinician role	
Advanced nurse practitioners	5 (12)
Chiropractors	7 (17)
General practitioners	4 (10)
Physician assistants	5 (12)
Physicians	10 (24)
Physiotherapists	4 (10)
Resident physicians	4 (10)
Specialist physicians	3 (7)

3.4.3 | Modifiable factors

Eleven (n = 11) studies reported modifiable factors that influence imaging CDM, which were divided into patient beliefs and clinician beliefs (Table 4).

Two (n = 2) studies reported the influence of patient beliefs on imaging CDM (Blokzijl et al., 2021; Jenkins et al., 2022). Patient beliefs were divided into three subcategories: imaging knowledge (n = 2; 100%), decision-making (n = 1; 50%), and desire for imaging (n = 2; 100%) (Table 4).

Eleven studies (n = 11) reported the influence of clinician beliefs on imaging CDM (Blokzijl et al., 2021; Bussières et al., 2012; de Zoete et al., 2022; Ely et al., 2018; Ganesh et al., 2022; Grimshaw et al., 2011; Le et al., 2018; Nevedal et al., 2020; Pike et al., 2022; Sears et al., 2016; To et al., 2022). Clinician beliefs were divided into six subcategories: consequences (n = 6; 55%), clinical practice (n = 8; 72%), knowledge (n = 6; 55%), social (n = 5; 45%), clinical setting (n = 4; 36%), and system structure (n = 5; 45%) (Table 4).

The factors influencing imaging CDM are explored in Table 5.

4 | DISCUSSION

4.1 | Summary of evidence

This scoping review explored the literature detailing factors that influence imaging CDM in LBP management. We categorised our findings into *clinical features*, *non-modifiable* and *modifiable* factors. Most studies reported non-modifiable factors that influence imaging CDM.

In this review, only two studies explored the influence of patient beliefs on imaging CDM. This low number of studies is surprising, given that a recent systematic review of qualitative literature found that clinicians report patient pressure for diagnosis as a key influence on their ability to adhere to LBP imaging guidelines (Hall et al., 2019). There is also a considerable body of literature exploring public opinion on imaging in LBP management. For example, the scoping review by Chou et al. (2018) found that people with LBP seek a diagnosis or cause from their clinician and believe imaging is necessary to do so. These findings are supported by a more recent systematic review of qualitative literature by Sharma et al. (2020) which showed that people with LBP believed that pathoanatomical findings on imaging were important to show that 'pain is real', validating their LBP experience. Sharma et al. (2020) also showed that patients and clinicians shared beliefs about the benefits of imaging, without recognising the potential risks. While this existing literature highlights the importance of patient beliefs and provides insight into their views on imaging, most do not directly explore their influence on clinicians imaging behaviour.

TABLE 2 Publications reporting clinical features influencing imaging clinical decision-making.

	Clinical features					
Reference	**Red flags**	**Pain**	**Neurological deficit**	**Cognitive/disability metrics**	**Presentation**	**Injury severity**
Barnett et al., 2020		✓				
Ely et al., 2018		✓	✓	✓		
Ferreira et al., 2019	✓				✓	
Graves et al., 2012		✓	✓	✓		✓
Kohns et al., 2018	✓	✓				
Loy et al., 2019				✓		
Peurois et al., 2022		✓				
Piccoliori et al., 2013		✓				
Schlemmer et al., 2015	✓					
Urrutia et al., 2020	✓		✓			

✓ indicates influencing factor was reported in this subcategory.

In contrast, we identified 11 studies that explored clinicians beliefs which influence imaging CDM. There was a prevailing theme of defensive medicine within these results. Defensive medicine is medical care with a primary focus on limiting the risk of litigation rather than helping the patient (Kakemam et al., 2022). This practice has been associated with inappropriate imaging and other unnecessary medical management (Kakemam et al., 2022). In our review, fear of litigation or malpractice claims was frequently reported to influence imaging CDM. However, many of these studies were conducted in litigious cultures, which may limit their generalisability to cultures operating under "no fault" medical systems. In addition to litigation, our review found literature showing that fear of missing a diagnosis and confidence to manage LBP influences imaging CDM. These findings align with existing literature demonstrating that a clinicians' duty of care to their patients may lead them to rely on imaging out of concern of missing a relevant finding, despite the potential risk of harm from imaging (Hall et al., 2019; Sharma et al., 2020). Clinicians are also more inclined to order imaging if this helps foster a stronger patient relationship, irrespective of clear clinical indications (Hall et al., 2019; Sharma et al., 2020). Such dilemmas present complex ethical challenges, encapsulating the balance between beneficence, or doing good, and non-maleficence, the principle of avoiding harm, which confronts clinicians daily.

Mass media campaigns have been used to influence clinician and patient beliefs by promoting a variety of public health messages including physical activity, smoking cessation, and sexual health (Stead et al., 2019). Two recent systematic reviews show that mass media campaigns can effectively alter public (Nkhata et al., 2019; Suman et al., 2021) and clinician beliefs about LBP and its management (Suman et al., 2021). In particular, the latter review found evidence that media campaigns can influence beliefs about the use of imaging in LBP management. Both reviews also found evidence that these campaigns may play a role in reducing disability behaviours and healthcare utilisation, including imaging. However, clinicians play an important role in reinforcing the messages from these campaigns to patients. Sharma et al. (2021) conducted focus groups with members of the public on their views on a health campaign encouraging judicious use of imaging in LBP management. Participants initially struggled to accept, or even mistrust the material, placing a higher level of trust in advice from their doctor than the campaigns. This reinforces previous literature demonstrating that clinicians strongly influence the beliefs of their patients about LBP management (Darlow et al., 2012) and highlights the need for a consistent message between campaigns and clinicians.

In addition to overt beliefs are unconscious biases, where clinician beliefs intersect with non-modifiable patient factors. Research has shown the damaging effect of unconscious bias on healthcare assessment, test ordering, and treatment recommendations (Fitzgerald & Hurst, 2017). For example, racial bias has been shown to influence opioid prescription and surgical intervention in the management of LBP, though the authors were unable to determine the influence on imaging due to low certainty of evidence (Chen et al., 2023). In our review, we found many studies reporting that patient characteristics such as sex, socioeconomic status, and ethnicity influenced imaging CDM, suggesting potential biases. Despite the well-documented correlation between unconscious bias and compromised quality of care, efforts to mitigate these biases through experimental interventions have had limited success (Vela et al., 2022).

The findings of our review present several implications for future research and clinical practice. There is a limited body of evidence exploring the influence of patient beliefs, despite being identified as a driver of clinician imaging behaviour (Hall et al., 2019). Few studies have considered imaging CDM in lower-middle income economies; these economies may contend with unique influences on CDM such

TABLE 3 Publications reporting non-modifiable factors influencing imaging clinical decision-making.

	Patient characteristics					Clinician characteristics						Clinical setting		
Reference	Age	Sex	Ethnicity	Socio-economic	Clinical history	Age	Sex	Experience (years)	Education	Role	Clinical practice	Geographical	Clinic characteristics	Service structure
Arishy et al., 2022										✓				
Barnett et al., 2020	✓	✓			✓	✓				✓	✓		✓	
Bouck et al., 2019	✓	✓		✓						✓	✓			
Bussières et al., 2013							✓	✓	✓		✓	✓	✓	
De Zoete et al., 2022								✓	✓			✓	✓	
Dietrich et al., 2018										✓				
Doll et al., 2022		✓												
Ely et al., 2018					✓									
Ferreira et al., 2019	✓	✓			✓									
Friedman et al., 2010	✓			✓										
Ganesh et al., 2022									✓					
Gidwani et al., 2016	✓		✓							✓			✓	
Graves et al., 2012	✓	✓	✓	✓	✓					✓				
Hong et al., 2017	✓		✓	✓							✓			
Kohns et al., 2018	✓		✓	✓										
Le et al., 2018											✓		✓	
Learman et al., 2014								✓					✓	
McCaughey et al., 2016	✓													
Pakpoor et al., 2020				✓								✓		
Peurois et al., 2022					✓									
Schlemmer et al., 2015	✓				✓								✓	
Sears et al., 2016								✓						
Tan et al., 2016	✓	✓	✓	✓	✓			✓	✓	✓	✓			
Traeger et al., 2021	✓	✓												
Urrutia et al., 2020	✓													
Zargar et al., 2014	✓			✓	✓					✓				✓

✓ indicates influencing factor was reported in this subcategory.

TABLE 4 Publications reporting modifiable factors influencing imaging clinical decision-making.

	Patient beliefs			Clinician beliefs					
Reference	Imaging purpose	Decision-making	Desire for imaging	Consequences	Clinical practice	Knowledge	Social	Clinical setting	Service structure
Blokzijl et al., 2021	✓	✓	✓	✓	✓		✓	✓	✓
Bussières et al., 2012				✓	✓	✓	✓		✓
Ely et al., 2018					✓				
Ganesh et al., 2022						✓			
Grimshaw et al., 2011				✓	✓	✓			✓
Jenkins et al., 2022	✓		✓						
Le et al., 2018					✓				
Nevedal et al., 2020				✓	✓	✓	✓	✓	✓
Pike et al., 2022				✓	✓	✓	✓	✓	✓
Sears et al., 2016				✓				✓	
To et al., 2022				✓	✓	✓	✓		✓

✓ indicates influencing factor was reported in this subcategory.

as limited healthcare resources or political instability (Salek et al., 2023). We have highlighted several modifiable factors which may aid efforts to improve imaging clinical practice. Implementing any change in imaging behaviour requires effective knowledge translation. This could be achieved using a co-design strategy including clinicians and patients (Grindell et al., 2022). Educational interventions targeting beliefs alone may be insufficient to influence clinical practice (Belavy et al., 2022; Kjelle et al., 2021). Instead, evidence suggests that multi-component interventions targeting the individual, policy and systemic levels may be more effective (Belavy et al., 2022; Johnson & May 2015; Kjelle et al., 2021). Strategies should provide clinicians with a clear understanding of the requirements placed upon them, supported by ongoing reference between external clinical expectations and their own clinical actions to create meaningful change (Johnson & May 2015). Potential strategies to challenge unconscious bias include healthcare system reform, increasing minority representation, promoting self-awareness (Vela et al., 2022) and addressing social determinants of health through health literacy and promotion of positive health messages (Rethorn et al., 2019).

4.2 | Limitations

Our review has several limitations. We did not apply limitations to the LBP duration or diagnosis and healthcare setting; therefore, the results should be cautiously considered in specific populations. Similarly, our review included multiple imaging modalities, requiring care if considering these results in relation to a specific imaging technique. Overlap between categories is possible, especially in reference to modifiable factors which may depend on context (Alwan et al., 2024). Our review included a diverse range of literature, enabling us to map the recent evidence and identify knowledge gaps. However, the heterogeneity of the included literature and the method of our analysis precluded definitive inference of the directional relationship between a given factor and imaging CDM.

5 | CONCLUSIONS

Clinical decision-making for imaging in LBP is shaped by three categories: clinical features, non-modifiable and modifiable factors. This research challenges the perception that imaging CDM is purely based on clinical features and objective findings. Patient and clinician characteristics, beliefs, and environment also play a role. Little is known about the influence of patient beliefs and there is evidence that unconscious bias influences imaging CDM. These factors are not always acknowledged and may result in inequitable and harmful use of imaging. These findings should be considered when developing strategies to reduce wasteful expenditure and potential clinical harm from inappropriate imaging.

TABLE 5 Factors influencing imaging clinical decision-making.

Category	Subcategory	Influences
Clinical features	Red flags	Red flags (not) present (Ferreira et al., 2019; Kohns et al., 2018; Schlemmer et al., 2015; Urrutia et al., 2020)
	Pain	Characteristics: Severity (Barnett et al., 2020; Ely et al., 2018; Graves et al., 2012), radicular or sciatic pain (Ely et al., 2018; Kohns et al., 2018; Peurois et al., 2022; Piccoliori et al., 2013) location (Ely et al., 2018), progression (Ely et al., 2018), duration (Ely et al., 2018)
	Neurological deficit	Neurological deficit (Ely et al., 2018; Graves et al., 2012; Urrutia et al., 2020), radiculopathy diagnosis (Graves et al., 2012)
	Cognitive/disability metrics	Disability (Graves et al., 2012; Loy et al., 2019), quality-of-life/mental health (Ely et al., 2018; Graves et al., 2012; Loy et al., 2019), maladaptive beliefs (Ely et al., 2018; Graves et al., 2012)
	Presentation	Arrival via ambulance (Ferreira et al., 2019), triage urgency (Ferreira et al., 2019)
	Injury severity	Documented severity rating (Graves et al., 2012)
Patient characteristics	Age	Age (Barnett et al., 2020; Bouck et al., 2019; Ferreira et al., 2019; Friedman et al., 2010; Gidwani et al., 2016; Graves et al., 2012; Hong et al., 2017; Kohns et al., 2018; McCaughey et al., 2016; Schlemmer et al., 2015; Tan et al., 2016; Traeger et al., 2021; Urrutia et al., 2020; Zargar et al., 2014)
	Sex	Sex (Barnett et al., 2020; Bouck et al., 2019; Doll et al., 2022; Ferreira et al., 2019; Graves et al., 2012; Tan et al., 2016; Traeger et al., 2021)
	Ethnicity	Ethnicity (Gidwani et al., 2016; Graves et al., 2012; Hong et al., 2017; Kohns et al., 2018; Tan et al., 2016)
	Socioeconomic factors	Income (Bouck et al., 2019; Graves et al., 2012), insurance (Friedman et al., 2010; Kohns et al., 2018; Pakpoor et al., 2020; Tan et al., 2016; Zargar et al., 2014), occupation and physical demands (Graves et al., 2012), education level (Hong et al., 2017; Zargar et al., 2014)
	Clinical history	Previous LBP episodes (Ely et al., 2018; Graves et al., 2012), comorbidities (Tan et al., 2016). Appointment history: Volume of previous LBP appointments (Barnett et al., 2020; Tan et al., 2016), (not) seeing assigned primary care clinician (Barnett et al., 2020), initial appointment versus follow up (Peurois et al., 2022). (Not) having prior treatment or imaging (Zargar et al., 2014). Logistics: Time arrived and duration spent at clinic (Ferreira et al., 2019), prevalence of observation/treatment room use (Schlemmer et al., 2015), year of appointment (Barnett et al., 2020)
Clinician characteristics	Age	Age (Barnett et al., 2020)
	Sex	Sex (Bussières et al., 2013)
	Experience (years)	Years (Bussières et al., 2013; de Zoete et al., 2022; Learman et al., 2014; Sears et al., 2016; Tan et al., 2016)
	Education	Level of qualification (de Zoete et al., 2022; Ganesh et al., 2022), school (Bussières et al., 2013) or country (Tan et al., 2016) in which qualification was obtained
	Role	Title/discipline (Arishy et al., 2022; Barnett et al., 2020; Bouck et al., 2019; Dietrich et al., 2018; Gidwani et al., 2016; Graves et al., 2012; Tan et al., 2016; Zargar et al., 2014),
	Clinical practice	Volume of LBP patients (Barnett et al., 2020; Bouck et al., 2019), ownership of imaging equipment (Hong et al., 2017), full time or part time (Bussières et al., 2013), prior patient did (not) get imaging (Hong et al., 2017)
Clinical setting	Geographical	Country (de Zoete et al., 2022), region (Bussières et al., 2013; Pakpoor et al., 2020), state (Pakpoor et al., 2020)
	Clinic characteristics	Urban, suburban or rurality (Bussières et al., 2013; Schlemmer et al., 2015), community versus hospital clinic (Barnett et al., 2020), department or clinic type (Bussières et al., 2013; Gidwani et al., 2016; Le et al., 2018; Learman et al., 2014), facility complexity (Gidwani et al., 2016), solo versus group employees (Bussières et al., 2013; de Zoete et al., 2022), on-site imaging facilities (Bussières et al., 2013)
	Service structure	Public versus private (Zargar et al., 2014)

(Continues)

TABLE 5 (Continued)

Category	Subcategory	Influences
Patient beliefs	Imaging knowledge	Imaging finds cause and validates pain, limited awareness of risks (Blokzijl et al., 2021), imaging is an important part of LBP management (Jenkins et al., 2022)
	Decision-making	Clinicians are the decision makers; yet patients may insist or seek 2nd opinion if disagree (Blokzijl et al., 2021), trust in clinicians (Blokzijl et al., 2021), having alternative treatments to imaging (Blokzijl et al., 2021), being provided information about clinical course of LBP (Blokzijl et al., 2021)
	Desire for imaging	Wanting imaging (Jenkins et al., 2022), patient circumstance/LBP experience (Blokzijl et al., 2021), external drivers to seek imaging: Insurance requirements (Blokzijl et al., 2021)
Clinician beliefs	Consequences	Fear of missing a diagnosis (Blokzijl et al., 2021; Bussières et al., 2012; Nevedal et al., 2020; Pike et al., 2022; To et al., 2022); reinforced by negative past experiences (Pike et al., 2022), fear of litigation (Bussières et al., 2012; Pike et al., 2022; Sears et al., 2016), cost to health system (To et al., 2022), ease of referral (Grimshaw et al., 2011). Effect on patients; exposure to radiation (Bussières et al., 2012; To et al., 2022), infectious diseases and adverse events (Bussières et al., 2012), mental wellbeing (Bussières et al., 2012; Pike et al., 2022; To et al., 2022), maintaining relationships (Pike et al., 2022), costs (Bussières et al., 2012), impact on treatment (To et al., 2022)/outcome (To et al., 2022), compliance (Bussières et al., 2012)
	Clinical practice	Guides: red flags (Pike et al., 2022), objective assessment (Blokzijl et al., 2021; Pike et al., 2022); compared to CPG's (To et al., 2022), gut feelings (To et al., 2022), habits (Grimshaw et al., 2011),past experiences (Bussières et al., 2012), response to treatment (Pike et al., 2022), radiology driven techniques (Bussières et al., 2012). Skills: Communication (Blokzijl et al., 2021; Pike et al., 2022; To et al., 2022), confidence to assess and manage LBP (Blokzijl et al., 2021; Bussières et al., 2012; Ely et al., 2018; Grimshaw et al., 2011; Pike et al., 2022; To et al., 2022); imaging safety net (Pike et al., 2022). Clinical identity: Professional autonomy (Bussières et al., 2012), competency (Grimshaw et al., 2011), resource stewardship (Grimshaw et al., 2011), evidence-based (Pike et al., 2022). External drivers: (dis)incentives (Bussières et al., 2012; Pike et al., 2022), referral requirements (Nevedal et al., 2020; Pike et al., 2022), insurance/compensation claims (Blokzijl et al., 2021; Pike et al., 2022), surgical candidacy, colleague requests (Pike et al., 2022). Behavioural regulators: Access to other clinicians, patient education material, decision support tools (Pike et al., 2022), previous imaging (To et al., 2022).
	Knowledge	(Un)familiarity/(un)awareness of CPG's (Bussières et al., 2012; Ganesh et al., 2022; Nevedal et al., 2020; Pike et al., 2022; To et al., 2022), (dis)agreement with CPG (Bussières et al., 2012; Nevedal et al., 2020; To et al., 2022) or formal education (Bussières et al., 2012), CPG quality/conflicting messages (Bussières et al., 2012; Pike et al., 2022), LBP aetiology (Grimshaw et al., 2011)/clinical course (Nevedal et al., 2020; To et al., 2022), awareness of LBP assessment/imaging indications (To et al., 2022), reliance on formal education/ongoing education (To et al., 2022), purpose of imaging (Bussières et al., 2012; Nevedal et al., 2020), purpose of CPG (Bussières et al., 2012)
	Social	Patient pressure (Blokzijl et al., 2021; Bussières et al., 2012; Nevedal et al., 2020); ability to resist pressure (Blokzijl et al., 2021; Nevedal et al., 2020); patient retaliation (Nevedal et al., 2020). Patient expectations (Blokzijl et al., 2021), knowledge (Blokzijl et al., 2021; Nevedal et al., 2020), value of imaging (Nevedal et al., 2020), receptiveness to education (Blokzijl et al., 2021). Maintaining relationships (Nevedal et al., 2020): Trust (Blokzijl et al., 2021), shared decision-making (Blokzijl et al., 2021), travel burden (Nevedal et al., 2020). Clinical identity: Credibility (Bussières et al., 2012), responsibility (To et al., 2022). Colleagues: Behaviour (To et al., 2022), knowledge, skills (Blokzijl et al., 2021; Bussières et al., 2012; Pike et al., 2022)
	Clinical setting	Time constraints (Blokzijl et al., 2021; Nevedal et al., 2020; Pike et al., 2022; Sears et al., 2016), patient locality (Pike et al., 2022)
	System structure	Guidelines, policies, protocols, or requirements (Bussières et al., 2012; Nevedal et al., 2020; To et al., 2022). Interdisciplinary continuity of care (Blokzijl et al., 2021), access (Pike et al., 2022), communication (To et al., 2022)

Abbreviations: CPG, clinical practice guideline; LBP, low back pain.

AUTHOR CONTRIBUTIONS

Luke Tanner, **Nicola L. Saywell**, **Julia Hill** and **Thomas Adams** were responsible for conceptualisation and design, with contributions from **Imran Khan Niazi**. **Luke Tanner** was responsible for preparation of the manuscript with contributions and review from **Nicola L. Saywell**, **Julia Hill**, **Thomas Adams** and **Imran Khan Niazi**.

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CONFLICT OF INTEREST STATEMENT

None.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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