FACTORS AFFECTING CHIROPRACTOR REQUESTS FOR FULL-LENGTH SPINAL RADIOGRAPHY: A SCOPING REVIEW

By Thomas Ramsay Readford

Completed under the Supervision of

Dr Melanie Hayes and Associate Professor Warren Michael Reed

Dissertation submitted in partial fulfilment of the requirements for the degree

Bachelor of Applied Science (Diagnostic Radiography) (Honours)

The University of Sydney

2021

THE UNIVERSITY OF SYDNEY

[redacted]

AUTHOR CONTRIBUTION STATEMENT

I hereby declare that this submission is my own work. It contains no material previously published or written by another person, except where acknowledged in the text. Nor does it contain material which has been submitted in other units of study outside of the Honours program. My writing for this thesis has developed and evolved with feedback from earlier submissions of my study proposal and research methods within the honours program, as well as feedback from peer review.

My contribution to the reported research project was as follows:

- I approached faculty staff with the original concept and rationale for this thesis.
- I contacted authors and facilitated discussions which were drawn upon as background information.
- I carried out the literature search for this project. The advice of an academic librarian was sought to refine the search strategy.
- I reviewed the literature bank for eligibility using Endnote X9.
- I charted the data used to outline existing evidence and synthesise new evidence using MS Excel.
- I carried out the analysis.
- The conclusions are my own, influenced by discussion with my supervisors and authors of cited literature.
- I sought permission from the honours coordinator and unit of study coordinator to submit the article for publication to the Journal of Medical Radiation Sciences.
- I prepared the article for submission to the Journal of Medical Radiation Sciences.
- I received feedback through peer review and made changes to the original article as suggested by two independent reviewers.

[redacted]

TABLE OF CONTENTS

COVER LETTER

Author 1
Sydney School of Health Sciences
Susan Wakil Health Building
East Avenue
UNIVERSITY OF SYDNEY
NSW 2006

Ms Cherry Agustin
Editor-in-chief
Journal of Medical Radiation Sciences (JMRS)

Dear Ms Agustin,
We wish to submit a revised manuscript of an original research article entitled '*Factors Affecting Chiropractor Requests for Full-length Spinal Radiography: A Scoping Review'* for peer review and potential publication in the Journal of Medical Radiation Sciences.

As we have outlined in our article, we firmly believe that this topic stands as an important issue which has been so-far underrepresented in radiological literature. The completion of chiropractor-referred radiographic examinations is a controversial topic that has relevance to practitioners working in the disciplines of radiology, chiropractic and indeed radiography. We have identified several key issues surrounding the continued utilisation of full-spine X-Rays by chiropractors, including a lack of quantitative measures to assess the utilisation of full-length spinal X-rays by chiropractors, a lack of consensus of what constitutes appropriate clinical justification for imaging and the existence of a spectrum of beliefs amongst chiropractic authors about the clinical utility and limitations of this type of examination.

For these reasons, we believe that our article will be of great interest to your readers and has the potential to draw attention to what is clearly an important and evolving professional issue.

Please find attached a revised manuscript as well as supporting evidence for our study.

Kind regards,

Author 1
Honours student – Medical Imaging Science
Sydney School of Health Sciences, The University of Sydney

Co-authors
Authors 2 & 3
Sydney School of Health Sciences, The University of Sydney

TITLE PAGE

Title:	Factors Affecting Chiropractor Requests for Full-length Spinal Radiography: A Scoping Review
Abbreviated title:	Chiropractor Requests for Full-spine X-rays
Word count:	241 (Abstract) 4995 (Introduction, Methods, Results, Discussion, Conclusion. References)
References:	34
Tables:	2
Figures:	2
Appendices:	A) Submission guidelines for authors (Journal of Medical Radiation Sciences) B) Completed PRISMA-ScR checklist C) Search strategy and eligibility criteria D) Search histories and results (AMED, EMBASE, MedLine and Scopus) E) Draft proof of the version of this manuscript previously submitted to the Journal of Medical Radiation Sciences for peer-review F) Decision letter from the editors of the Journal of Medical Radiation Sciences G) Feedback from Reviewer 1 (JMRS) H) Feedback from Reviewer 2 (JMRS) I) Author's reply to reviewers' comments J) Link to online supplementary evidence library
Acknowledgements:	Ms Elaine Tam, Academic Librarian at the University of Sydney Dr Hazel Jenkins, Chiropractor Academic at Macquarie University
Disclosure statement:	No conflicts of interest are declared by the authors. No funding was sought nor received for this project. Access to commercial databases was provided by the University of Sydney.

NOTE TO EXAMINERS

This thesis is presented in the format of a journal manuscript. Formatting complies with the author guidelines of the Journal of Medical Radiation Sciences (see Appendix A) with the following exceptions, as allowed by the Honours Thesis rules:

1. The abstract is structured
2. Five MeSH/CINAHL keywords are used
3. The tables and figures appear where they would in the text for ease of reading.
4. Appendices are provided
5. Though the guidelines state that there is no preferred referencing format, Vancouver referencing has been used throughout the manuscript.

These variations are allowed by Honours Thesis rules in acknowledgement that a) this thesis is not expected to be submission ready, and b) examiners may require more evidence of a student's understanding than a shorter article may allow.

Approval was given from the honours coordinator and unit of study coordinator to submit a previous version of this article: *Factors Affecting Chiropractor Requests for Full-length Spinal Radiography: A Scoping Review* to the Journal of Medical Radiation Sciences for review (see Appendix E). Feedback was received from peer-review (see Appendices F-H), and a revised manuscript has since been resubmitted to the journal for consideration and is presented in the following manuscript. It is therefore likely that this thesis will register a high degree of duplication if anti-plagiarism screening software is employed upon submission. For reasons of transparency, correspondence to and from the Journal of Medical Radiation Sciences pertaining to this article have been included in Appendices E through I.

ABSTRACT

INTRODUCTION: Chiropractors often refer their patients for full-length (three to four region) radiographs of the spine as part of their clinical assessment, which are frequently completed by radiographers in medical imaging practices. Overuse of spinal radiography by chiropractors has previously been reported and remains a contentious issue.

AIM: The purpose of this scoping review was to explore the issues surrounding the utilisation of FLS radiography by chiropractors and examine the alignment of this practice with current evidence.

METHOD: A search of four databases (AMED, EMBASE, MedLine and Scopus) and a hand search was conducted using key words. Articles were screened against an inclusion/exclusion criterion for relevance. Themes and findings were extracted from eligible articles and evidence was synthesised using a narrative approach.

RESULTS: In total, 25 articles were identified, six major themes were extracted, and subsequent conclusions drawn by authors were charted to identify confluent findings. This review identified a paucity of literature addressing this issue and an underrepresentation of relevant perspectives from radiographers. Several issues surrounding the use of full-length spinal radiography by chiropractors were identified and examined, including barriers to the adherence of published guidelines for spinal imaging, an absence of a reporting mechanism for the utilisation of spinal radiography in chiropractic and the existence of a spectrum of beliefs amongst chiropractors about the clinical utility and limitations of full-length spinal radiography.

CONCLUSION: Further investigation is required to further understand the scope of this issue and its impacts for radiation protection and patient safety.

Keywords: Chiropractic, Radiography, X-Rays, Diagnostic Imaging, Evidence-Based Practice

MANUSCRIPT

Introduction

Chiropractors are registered health practitioners who perform manual therapies to treat a myriad of health conditions.[1] Among the historical principles of chiropractic medicine is the belief that peripheral ailments of various aetiology are the result of a blockages of the body's innate energy.[2] These blockages are said to be caused by minute misalignments of the spinal column termed 'chiropractic vertebral subluxations' (CVS), which can ostensibly be treated through manual adjustment and identified using spinal radiography.[3, 4] Beliefs such as these are disputed even by some in the chiropractic community[5] and have to some extent pushed chiropractic to the periphery of the broader Australian health care system. However, chiropractic remains a prominent health profession in Australia, with a substantial client base in the community.[1]

As registered health practitioners, Australian Chiropractors can refer their patients for diagnostic investigations, including radiological studies, based on appropriate clinical indications.[6] Frequently, chiropractors refer their patients for full-length spinal (FLS) X-Rays, to assess for underlying pathological and structural changes which may have some impact upon their treatment.[4, 7] Between 2014 and 2015, approximately 130,000 three-to-four region spinal X-rays were performed in Australia.[7, 8] Most were requested by chiropractors.[7, 8] In Australia, radiographers are often requested to complete FLS X-ray examinations by chiropractors.[1] In keeping with their professional responsibilities as health care practitioners, radiographers and referring chiropractors must exercise judgment in determining whether a requested examination is justified in the context of currently available evidence and the known risks of unnecessary diagnostic investigations.[6, 9] There is conflicting evidence to support the continued use of FLS radiography in chiropractic[5, 10, 11], which in turn has made this issue a focal point for controversy in chiropractic academia.[4]

Therefore, the completion of chiropractor-requested FLS X-rays may present a challenge to the foundations of evidence-based practice and should be considered an important issue with impacts for both radiographers and chiropractors.[5, 11] The purpose of this scoping review was to explore the issues surrounding the utilisation of FLS radiography by chiropractors and examine the alignment of this practice with current evidence.

Methods

Protocol

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses - Scoping review extension (PRISMA-ScR) checklist was used for this review.[12] The methodology used was adapted from the proposed methodology for conducting a scoping review set out by Sucharew and Macaluso (2019).[13]

Search Strategy

An initial search was conducted in April 2021 using variations of the keywords "chiropractic", "spinal manipulation", "X-ray" and "radiograph" in four databases: AMED, EMBASE, Medline and Scopus. A hand search of Google was conducted using the same parameters to identify grey literature. Titles and abstracts were then reviewed for eligibility by the authors, followed by a full-text review of eligible articles. Forward and backward citation searching was implemented to identify additional eligible articles. Select authors were also contacted individually for background information which was later used during evidence synthesis.

Eligibility Criteria

Articles were included if they investigated FLS X-ray utilisation by chiropractors. Position statements from regulatory and professional bodies were also included in evidence synthesis. Search results were limited to articles published between 2010 and 2021 to ensure evidence reflected current attitudes and knowledge. Articles needed to address full-length spinal radiography, defined as imaging which includes the cervical, thoracic, lumbar and/or sacral spine[7, 8] to be eligible for inclusion in the data pool. Technical articles which investigated image quality and radiation dose in FLS X-ray examinations were also included irrespective of referring discipline, as this was not deemed to be relevant in the context of establishing the limitations of the examination itself. Articles which specified that they examined the utilisation of FLS X-Rays by practitioners of disciplines other than chiropractic were excluded, as were case reports, small cohort studies and opinion pieces. Articles where conflicts of interest or funding sources which may impact the validity of findings reported were excluded. Articles published in languages other than English were also excluded.

Data Charting Process

Data were charted according to the alignment of eligible articles with key themes identified during a full-text review. Data was charted by Investigator 1, then reviewed by Investigators 2 and 3. Disagreements in the classification of data were resolved through discussion between authors.

Evidence Synthesis

Conclusions drawn by authors were explored and described in the context of the themes extrapolated during the full-text review of eligible articles. Issues surrounding the utilisation of FLS X-Rays by chiropractors were explored and gaps in knowledge were described through a narrative approach.

Results

A total of 786 records were identified in the initial database search. After removing duplicates, 471 titles and abstracts were screened, with 71 full text papers assessed for eligibility. A total of 50 records were excluded for not meeting the inclusion criteria. Six records were excluded due to concerns raised by the authors about declared funding sources, which were perceived to be a source of potential bias. Ten additional articles were found through hand searching and forward & backward citation searching. In total, 25 eligible articles were included in the review (n = 25).

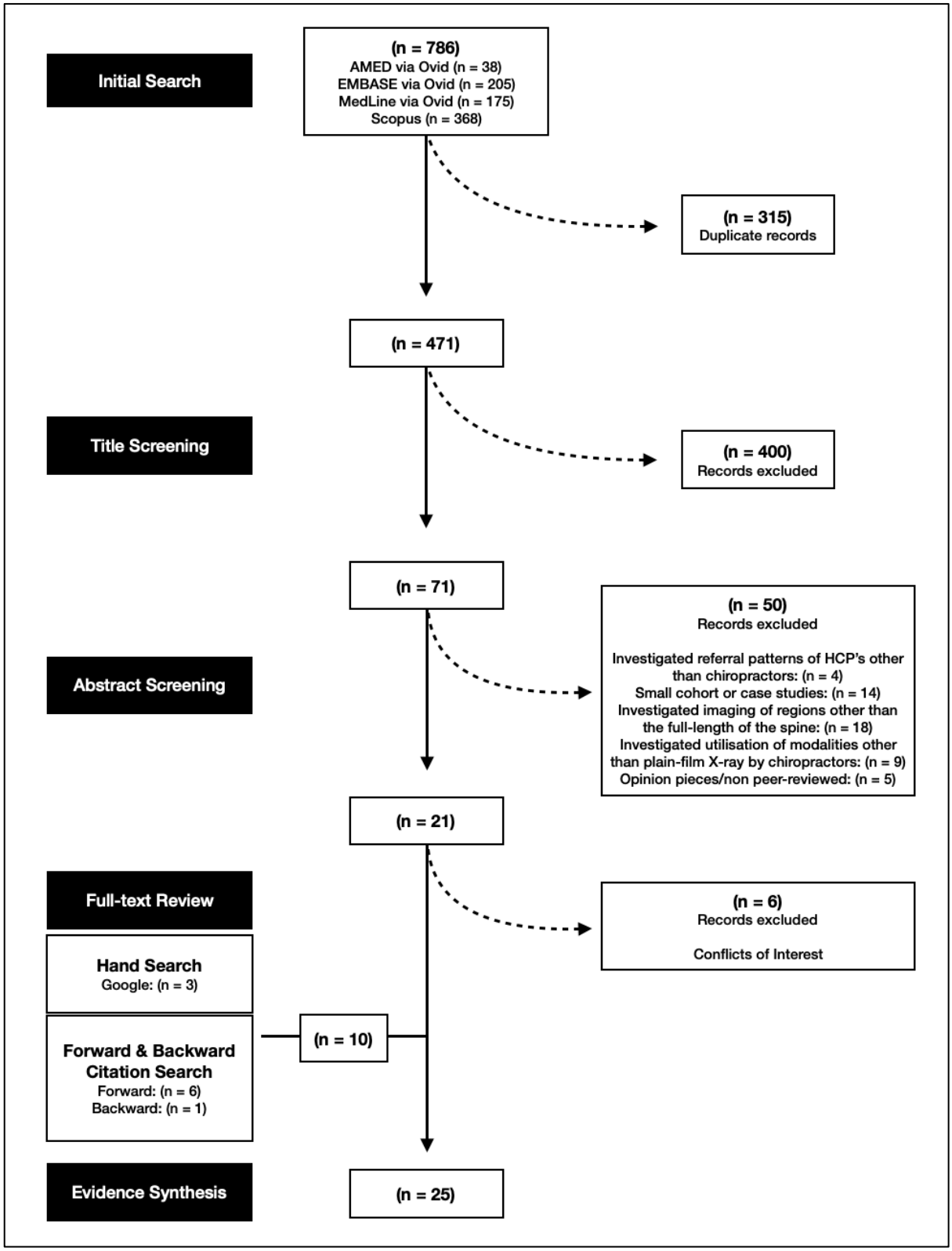

Figure 1 - Flow diagram showing sources of data.

Study Characteristics

21 of the 25 eligible articles (84%) examined in this review were written by authors with a background in chiropractic.[2-5, 10, 11, 14-28] A total of 11 of the eligible articles were reviews of existing literature, which examined evidence surrounding the use of FLS X-rays in chiropractic in isolation, or as a part of wider studies examining the utilisation of medical imaging by chiropractors.[2-5, 11, 18, 22, 24, 25, 28] Seven cross-sectional studies were identified, which investigated knowledge of and adherence to established guidelines for the utilisation of medical imaging, including FLS X-rays in chiropractic and explored how knowledge of these guidelines impacted imaging referral patterns.[10, 15-17, 20, 26, 27] Populations and perspectives were regionally diverse, with predominant author representation from Australia, North America and Europe. Our review was not able to identify any literature authored by radiographers which addressed chiropractor referrals for FLS radiography, which could be indicative of the wider underrepresentation of relevant perspectives from radiographers in discussions surrounding this issue.

Thematic Extraction

There were six major themes were present throughout the reviewed articles; *(1) The historical integration of FLS radiography in chiropractic, (2) Clinical indications for FLS radiography in chiropractic, (3) Current trends in the use of imaging services and equipment for FLS radiography by chiropractors, (4) Risks associated with FLS radiography, (5) Chiropractic techniques which prescribe the use of FLS radiography* and *(6) Current trends in the utilisation of FLS radiography in chiropractic.*

Table 1 – Characteristics of Included Studies

ID Author, Year	**Region/ Population**	**Classification/ Study Design**	**Discipline of Lead Author**	**Relevant Themes**					
				1. The historical Integration of FLS radiography in chiropractic	2. Indications for FLS radiography	3. Trends in the use of imaging services and equipment by chiropractors	4. Risks associated with FLS radiography (see Table 2)	5. Chiropractic techniques which prescribe the use of FLS radiography	6. Current trends in the utilisation of FLS radiography by chiropractors
Alcantara, 2010[14]	Canada	Cross-sectional descriptive survey	Chiropractor					•	
Bussieres, 2010[15]	Switzerland	Randomised trial interventional study with postal follow-ups	Chiropractor		•				
Bussieres, 2013[17]	USA	Cross-sectional retrospective analysis	Chiropractor		•				•
Bussieres, 2014[16]	USA	Interrupted time series analysis	Chiropractor		•				•
Coleman, 2011[19]	USA	Simulated technical study	Chiropractor				•		
Coleman, 2013[18]	USA	Historical review	Chiropractor	•				•	
Corso, 2020[11]	Canada	Rapid review	Chiropractor		•		•	•	•
De Carvalho, 2021[20]	Canada	Cross-sectional survey	Chiropractor						•
Department of Health, 2017[7]	Australia	Government publication	N/A			•			•
Harrison, 2018[4]	USA	Review	Chiropractor		•		•	•	•
Jenkins, 2016[10]	Australia	Cross-sectional survey	Chiropractor		•	•	•	•	•
Jenkins, 2018[5]	Australia	Narrative	Chiropractor		•	•	•	•	•

Continued below…

ID Author, Year	**Region**	**Classification/ Study Design**	**Discipline of Lead Author**	**Relevant Themes**					
				1. The historical Integration of FLS radiography in chiropractic	2. Indications for FLS radiography	3. Trends in the use of imaging services and equipment by chiropractors	4. Risks associated with FLS radiography (expanded in Table 2)	5. Chiropractic techniques which prescribe the use of FLS radiography	6. Current trends in the utilisation of FLS radiography by chiropractors
Johnson, 2019[21]	USA	Editorial	Chiropractor	•					•
Law, 2016[29]	Hong Kong	Simulated technical study	Radiologist				•		
MBS Review Taskforce, 2016[8]	Australia	Professional Consultation Committee report	Multidisciplinary committee			•	•		•
Mogaadi, 2012[30]	Tunisia	Retrospective quantitative analysis	Biologist				•		
Oakley, 2020[3]	USA	Review	Chiropractor		•	•	•	•	•
Simpson, 2019[22]	Australia	Historical review	Chiropractor	•		•			
Walker, 2011[23]	Australia	Cross-sectional survey	Chiropractor		•				•
Young, 2014 (I)[24]	Australia	Historical review	Chiropractor	•				•	
Young, 2014 (II)[25]	Australia	Historical review	Chiropractor	•				•	
Young, 2016[2]	Australasia, North America, UK, Europe	Historical review	Chiropractor	•				•	•
Young, 2017 (I)[26]	Australasia, North America, UK, Europe	Survey	Chiropractor	•				•	
Young, 2017 (II)[27]	Australia	Thematic analysis	Chiropractor	•				•	
Young, 2019[28]	Australia	Historical review	Chiropractor	•				•	

Theme One - The historical integration of FLS radiography in chiropractic

Nine eligible articles addressed the historical integration of FLS radiography in chiropractic.[2, 18, 21, 22, 24-28] Articles outlined the early uses of FLS radiography or 'spinography' by chiropractors to attempt to confirm vertebral subluxation theory. CVS was first described by chiropractic's founder, D.D. Palmer, in 1895 as a minute misalignment of the vertebrae of the spine, which in turn could impinge a nerve and interrupt the flow of vital force; a concept derived from a central belief in innate intelligence and vitalism. Palmer termed these misalignments to be 'subluxations', appropriating established medical terminology for the displacement of a joint from its normal physiological position. Today, CVS as defined by Palmer has yet to be proven to exist definitively, with limited evidence to support its validity as a principle of chiropractic care or physiological construct.[24] There was a marked lack of crossover between articles which examined the historical role of FLS radiography in chiropractic and those which examined the risks associated with the use of FLS radiography (Theme 4), which may be reflective of the contemporary scientific understanding of the risks exposure to ionising radiation which early chiropractic practitioners may not have fully appreciated. Authors were able to draw direct and indirect lineages between chiropractic techniques still practiced today and the teachings of BJ Palmer, the patriarch of chiropractic radiology.[2, 24, 25] The findings of these articles substantively confirm the use of spinography in the past and by some still in contemporary chiropractic to detect CVS.[2, 24, 25]

Theme Two - Clinical indications for FLS radiography

Of the 25 eligible articles, nine described guidelines for the appropriate use of FLS radiography in chiropractic or examined awareness and adherence to those guidelines in practice.[3-5, 10, 11, 15-17, 23] The Australian Medicare Benefit Schedule Review Taskforce's committee for diagnostic imaging in low-back pain concluded that the clinical indications for FLS radiography are limited primarily to the continuing management of patients with scoliosis, which could typically be managed by a spinal specialist physician as opposed to a chiropractor.[8] Authors concluded that chiropractors had low self-reported knowledge of guidelines for the referral of patients for imaging for low back pain, including the use of FLS radiography.[10, 16, 17] One study concluded that only 50% of practicing Australian chiropractors had

knowledge or awareness of evidence-based guidelines for imaging in low-back pain.[10] That same study found that up to 20% of chiropractors believe that atraumatic low back pain is an appropriate indication for the referral of patients for FLS radiography[10], despite strong evidence suggesting that plain-film spinal radiography of any region is not indicated in the initial clinical management of this common presentation.[5, 10, 23] Authors also described the use of 'routine' or repeated radiography of the spine to monitor progressive structural changes.[5, 11] It was largely concluded that repeat radiography of the whole spine should be discouraged as a practice, as it defies current evidence for the appropriate utilisation of spinal radiography.[5, 11]

The use of FLS radiography as a screening tool for "red flags" was examined in several papers.[3, 5, 10, 11] Red flags are underlying spinal pathology which would prevent a chiropractor from being able to safely manipulate a patient's spine and whose management requirements would exceed their scope of practice i.e., metastases, Paget's disease, infection.[5, 11] The use of FLS radiography as a screening tool for the identification of pathology commonly cited as a red flag by chiropractors without clinical suspicion of disease is discouraged.[5, 11] It was determined that the technical limitations of plain-film radiography also render these examinations insensitive for the detection of many red flag pathologies, with spinal magnetic resonance imaging and computed tomography deemed more sensitive than FLS radiography.[5] However, where clinical suspicion of disease which may exceed the scope of chiropractors exists, it could be argued that timely referral to a physician (who may have greater access to MRI and CT) may confer more benefit to patients rather than chiropractic referrals for FLS radiographic investigations.[5] The sparse evidence surrounding the use of FLS radiography for the screening of red flags both with and without clinical suspicion of underlying pathology brings into question the alignment of these practices with current evidence. Further research is required to determine the scope of this issue as it exists today.

Theme Three - Current Trends in the use of imaging services and equipment for FLS radiography by chiropractors

Six articles were identified which examined current trends in the referral of patients to medical imaging services for FLS radiography by chiropractors, as well as

the availability of medical imaging equipment used for spinal radiography to chiropractors.[3, 5, 7, 8, 10, 22] As part of their clinical training chiropractors are trained in general radiographic techniques and can obtain radiation usage licenses for the operation of radiographic equipment in their practices.[5, 10] The ownership of radiographic equipment by chiropractors was determined to be a possible cause of increased utilisation of FLS radiography in practice.[5] It remains unclear what proportion of chiropractors opt to perform their own radiography or otherwise preferentially refer their patients to medical imaging practices for the completion of a spinal X-ray series. It is also unclear how the decision to refer patients to medical imaging practices for these series' impacts on the completion of the examination itself and how clinical justification is assessed in this setting, given the specialist nature of chiropractic techniques which could be considered esoteric.[5, 10, 22] Further research is required to understand the dynamics at play in the completion of chiropractor requested FLS radiography by radiographers in medical imaging practices.

Theme Four - Risks associated with FLS radiography

This review identified nine eligible articles addressed this theme.[3-5, 8, 10, 11, 18, 29, 30] There was significant variation between the conclusions drawn by authors about whether exposure to ionising radiation during FLS radiography carried a risk of inducing cancer later in life, with authors advocating for both the liberal and conservative utilisation of FLS radiography by chiropractors.[3-5, 10] Two technical studies were identified which quantified effective radiation dose for FLS radiography in AP and lateral projections as well as the likelihood of inducing cancer secondary to undergoing annual FLS radiographic examinations.[29, 30] Technical data also described the limitations of FLS radiography as a radiographic projection, with impacts on the reliability of measurements obtained as part of chiropractic biomechanical analysis techniques.[19] Aside from the established risks of inducing cancer from FLS radiography, authors also described economic and diagnostic risks associated with the overutilisation of spinal radiography in chiropractic, including waste, false reassurance and overdiagnosis of pathology with limited diagnostic benefit conferred to patients.[5, 10, 11] A breakdown of the conclusions authors drew with regards to the risks associated with FLS radiography is included in Table 2.

Table 2 – Author's conclusions regarding the risks associated with FLS radiography (Theme Four)

ID Author, Year	Classification of conclusions drawn by authors				Synopsis/supporting evidence
	4a. FLS X-rays carry a risk of inducing cancer	4b. FLS X-rays carry a negligible risk or do not carry a risk of inducing cancer	4c. FLS X-rays carry risks other than cancer i.e., economic burden, overdiagnosis	4d. FLS X-rays are technically limited as a diagnostic investigation	
Coleman, 2011[19]				•	▪ Coleman compared simulated degrees of beam divergence as a determinant of image quality between an anteroposterior (AP) FLS X-ray at 84 inches focal-film distance (FFD) and selected sectional spine views at 40 inches FFD.[19] ▪ Coleman described the shortcomings of the AP FLS projection with respect to distortion of anatomical features used for measurement by chiropractors including projected axial rotation and ilium length.[19] ▪ It was determined that the distortion was caused by the increased FFD required to obtain an FLS X-ray.[19]
Corso, 2020[11]	•				▪ In a rapid review of 23 articles investigating the clinical utility of routine and repeat radiography of the spine in chiropractic, Corso *"found no evidence that radiographs used to assess the function or structure of the spine improves patients' outcomes"*[11] ▪ Corso argued that radiography of the spine is still indicated for the investigation of "red flags"; pathology which would prevent a chiropractor from being able to safely manipulate a patient's spine i.e. metasteses[11]
Harrison, 2018[4]		•			▪ In response to the American Chiropractic Association's (ACA) endorsement of the 'Choosing Wisely' initiative and advocacy for the conservative utilisation of spinal imaging in chiropractic, Harrison argues that restricting spinal imaging, including FLS radiography, puts patient safety at risk and that the position of the ACA is *"not consistent with the views of large factions of the profession that routinely X-ray their patients".*[4] ▪ Although Harrison does not specifically address the risk of inducing cancer from FLS radiography, the author frequently cites articles which argue that there is a non-existent or negligible risk of inducing cancer from spinal radiography as evidence against the ACA's position[4] ▪ Harrison is also listed as a contributor in (Oakley, 2020)[3]
Jenkins, 2016[10]	•				▪ In a cross-sectional survey examining knowledge of and adherence to guidelines for the imaging of atraumatic low-back pain by chiropractors (LBP), Jenkins concluded that reported knowledge and adherence to published guidelines amongst Australian chiropractors was low and needed to be improved.[10] ▪ Described a likely association between the use of FLS radiography as prescribed by certain chiropractic techniques i.e. Gonstead and Chiropractic BioPhysics in the presence of LBP and poor adherence to guidelines which discourage the use of radiography for the investigation of LBP[10]

Continued below…

ID Author, Year	Classification of conclusions drawn by authors				Synopsis/supporting evidence
	4a. FLS X-rays carry a risk of inducing cancer	4b. FLS X-rays carry a negligible risk or do not carry a risk of inducing cancer	4c. FLS X-rays carry risks other than cancer i.e., economic burden, overdiagnosis	4d. FLS X-rays are technically limited as a diagnostic investigation	
Jenkins, 2018[5]	•		•	•	▪ In a narrative review of literature, Jenkins outlined current evidence for the use of spinal radiography in chiropractic, including FLS radiography ▪ Jenkins opines that although the risk of inducing cancer from exposure to ionising radiation should not be a barrier to ordering imaging where it is clinically justifiable, *"it should be assumed that that some level of risk is associated with X-rays"*.[5] ▪ Jenkins also discussed risks aside from inducing cancer, including waste, false reassurance and over/underdiagnosis of pathology and a lack of evidence to support the continued use of spinal radiography as a screening tool for 'red flags', citing its lack of specificity for common spinal pathology which would be considered a red flag.[5]
Law, 2016[29]	•				▪ Cumulative organ absorbed doses of repeat AP and lateral FLS X-rays for progressive scoliosis imaging, performed on an annual basis were simulated and a lifetime attributable cancer risk was calculated as 0.08-0.17%.[29] This finding demonstrates a correlation between FLS radiography and the onset of cancer as a stochastic effect of exposure to ionising radiation.[29]
MBS Review Taskforce, 2016[8]	•		•		▪ The Medicare Benefit Schedule (MBS) review taskforce's diagnostic imaging clinical committee for imaging for LBP concluded that at the time the committee submitted its report (c.2016), there was marked overutilisation of FLS radiography by Australian chiropractors.[8] ▪ The committee noted that three to four-region spinal X-rays have limited clinical utility but did concede that they were useful in the assessment of scoliosis. It went on to note that the management of scoliosis would preferentially be undertaken by spinal specialists as opposed to primary care providers i.e. chiropractors.[8]
Mogaadi, 2012[30]	•				▪ Mogaadi performed a retrospective analysis of radiation doses encumbered upon patients undergoing FLS radiography as part of the assessment of scoliosis, and was able to quantify an effective dose range of between 118 to 1596 μSV for an AP FLS projection and 97 to 1370 μSV for a lateral FLS projection.[30] ▪ Mogaadi stipulated that effective dose is a primary indicator of radiation risk of malignancy.[30]
Oakley, 2020[3]		•			▪ Secondary to Harrison's refutation of the position of the ACA to endorse the 'Choosing Wisely' imaging reduction movement, Oakley asserts that infrequent X-ray use is not associated with increased risk of cancer and that "any guidelines…alluding to dangerous patient radiation exposures as a rationale to avoid imaging is not an evidence-based argument" ▪ Oakley also disputes key arguments put forth by the ACA and other authors as causation to reduce spinal radiography usage in chiropractic, including economic waste and risks of over and underdiagnosis.[3]

Theme Five - Chiropractic techniques which prescribe the use of FLS radiography

A total of 13 articles described the use of FLS radiography as prescribed by contemporary chiropractic techniques or treatment systems.[2-5, 10, 11, 14, 19, 22, 24-28] Six published techniques were identified which require the use of FLS radiography including the *Gonstead, Chiropractic BioPhysics, Applied Spinal Biomechanical Engineering, Universal Chiropractic College, Pierce/Stillwagon, Spinal Stressology* and *Logan* tehcniques.[4, 5, 11, 24] Authors described a strong correlation between the use of these techniques and increased reliance on FLS radiography, suggesting incongruity between adherence to guidelines for spine imaging and the pressure placed on chiropractic practitioners to adhere to the requirements of a given technique system.[10, 11] As such the use of spinal radiography as part of a specific technique may be a barrier to the appropriate use of FLS radiography in practice.[5, 10] There is a lack of high-quality evidence to suggest that radiographic measurements taken from FLS X-rays as part of treatment following a chiropractic technique system such as the Chiropractic BioPhysics system are clinically relevant or have any bearing in the outcomes afforded to patients.[11] This review did not examine the effectiveness or credibility of techniques which use FLS radiography and or the role of FLS radiography as a part of individual chiropractic techniques. Indications for the use of techniques requiring FLS radiography in practice were also not examined, however it is apparent that the use of chiropractic techniques which incorporate FLS radiography can precipitate the use of FLS radiography where it is otherwise not indicated.[5, 11, 24]

Theme Six - Current trends in the utilisation of FLS radiography by chiropractors

This review identified 13 eligible articles which addressed this theme.[2-5, 7, 8, 10, 11, 16, 17, 20, 21, 23] The strength of evidence authors used to draw conclusions about the reliance of chiropractors on FLS radiography was lacking. Measures used by authors to determine referral patterns through survey responses were largely self-reported or framed in a hypothetical context.[10, 20, 26, 27] Retrospective studies which examined the use of FLS radiography in a given population of chiropractic practitioners suggested differences in education, the availability of medical imaging equipment and knowledge of diagnostic imaging guidelines as determinants of utilisation.[5, 10, 11] This review also examined changes made to the Medicare Benefit Schedule (MBS) in 2017, which limited the ability of chiropractors to refer patients for MBS-reimbursed

FLS radiography.[7, 8] These changes were made after a taskforce determined that FLS radiography was being overutilised by chiropractic referrers and was implemented ostensibly to dissuade reliance on this examination.[7, 8] However, the changes did not remove the ability of chiropractors to order FLS X-rays entirely and today chiropractors are still able to order FLS radiographic examinations which do not attract a Medicare benefit.[7] Incidentally, the introduction of these changes also removed the only reliable measure of the number of FLS X-rays being performed in Australia today; a measure which was previously used as a cause for reform.[8] Therefore, it is difficult to determine whether the changes enacted in 2017 were effective in their goal of reducing the number of FLS X-rays ordered by chiropractors.

Discussion

The results of this review point to the existence of a spectrum of beliefs and knowledge amongst chiropractic practitioners surrounding the appropriate use of FLS radiography which may not always align with the principles of evidence-based practice.[2, 7, 8, 10, 16, 17, 20] It should be noted from the outset that in many ways the issue of inappropriate or unnecessary referrals for medical imaging and other diagnostic investigations is not an issue which is exclusive to chiropractors.[8, 9, 31] In the context of the wider discussions surrounding the appropriate use of medical imaging; particularly spinal imaging, overutilisation and departures from established imaging guidelines have been reported extensively amongst medical practitioners.[8] As such, the issue at hand is not whether overutilisation of FLS radiography can be attributed to chiropractors as alternative health practitioners or chiropractic as a discipline.[3, 4] Rather, the issue, which is underscored by the findings of this review, is how health professionals can work collaboratively to ensure the judicious, evidence-based use of FLS radiography which better aligns with the delivery of quality health outcomes for patients.

The risks associated with overutilisation of diagnostic imaging are well documented.[5, 7, 10, 11, 16, 20, 29, 30] Aside from the inherent risks of unnecessary exposure to ionising radiation, increased reliance on diagnostic imaging by any practitioner in the absence of sufficient clinical justification increases economic burdens encumbered upon the health care system. As such FLS radiography should be considered a finite resource and should be used judiciously to ensure risks associated with its use are minimised, thus ensuring that it

remains available to chiropractors and other practitioners where its use is clinically justified.[6, 8] Imaging which is not clinically indicated also carries a risk of overdiagnosis; that being the radiological diagnosis of disease which does not ultimately impact on a patient's course of treatment.[5] In a narrative review, Jenkins concluded that in chiropractic applications of spinal radiography, this could include the diagnosis of incidental degenerative changes such as osteophyte formation, reduced disk height and spondylolisthesis.[5] These findings are common, but show poor correlation with clinical symptoms and render no benefit for patients undergoing treatment.[5] Furthermore, the reported use of FLS radiography by chiropractors for the detection of red flags in the absence of any significant clinical indications for imaging could also be considered a practice which also carries a high risk of overdiagnosis.[5, 10, 11, 17] Ironically overutilisation of FLS radiography may also lead to an increased risk of missed or underdiagnosis; a failure to detect early pathological changes due to the insensitivity of a diagnostic test (Type II error).[5] Plain film X-rays have a significant insensitivity to early structural changes in bone, suggestive of an acute pathology and as such the continued use of FLS radiography to identify changes of this nature as part of screening for red flags may not be consistent with current evidence.[5]

For radiographers, the completion of imaging which is clinically unjustified stands as a challenge to their professional responsibilities as health practitioners, and the guiding principles of radiation safety.[9, 31] In practice, radiographers must ensure that the imaging examination they have been asked to perform by a referring practitioner is appropriate in the context of the clinical information and the known risks of exposure to ionising radiation.[9, 31] This responsibility is aligned with the ALARA (As Low as Reasonably Achievable) principle of radiation safety, which stipulates that the use of ionising radiation should be conservative, clinically appropriate and justified when weighed against the known risks of exposure to ionising radiation, namely the risk of inducing cancer later in life.[5, 9, 31] The wider responsibility to assess whether the risks of a patient undergoing radiographic imaging outweigh the diagnostic benefit of the examination lies primarily with the referring practitioner who instigates a request for imaging, however radiographers have an important role to play in the assessment of clinical justification in medical imaging.[9, 31] Barriers to the assessment of clinical justification by radiographers have been described including differences in education and medical dominance.[9] These barriers are compounded in the case of chiropractor requested FLS radiography, by a lack of shared knowledge which could be bridged with further research and improved dialogue with chiropractic practitioners.

In the context of FLS radiography utilisation by chiropractors, overutilisation has previously been reported and may still be prevalent today.[7, 8] The introduction of the 2017 changes to MBS reimbursement for three and four region spinal radiography have precipitated a substantial decline in the number of MBS-compensated three and four region spinal X-rays completed in the four years since the changes were enacted.[32] By comparison in the same period, the number of MBS reimbursed two region spinal X-rays completed rose dramatically.[33]

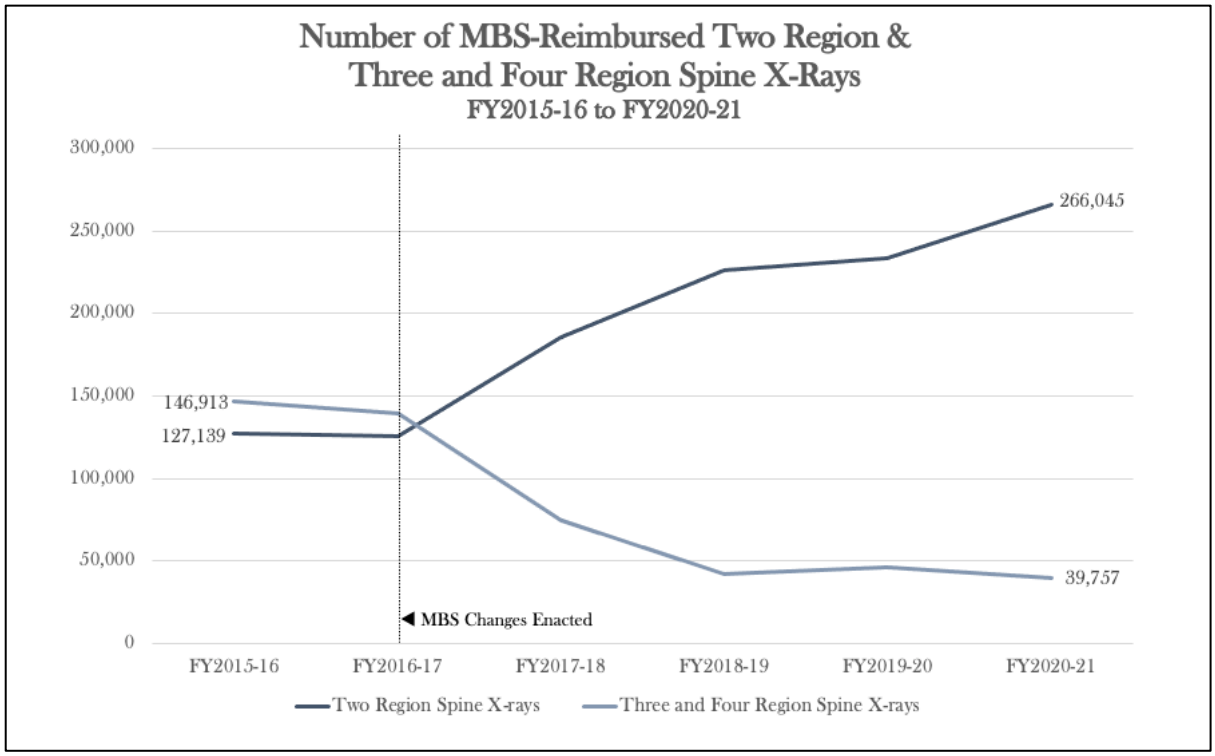

Figure 2 - Number of MBS-reimbursed two region & three and four region Spine X-rays (FY2015-16 to FY2020-21)[32, 33]

The relevance of this finding in the context of chiropractor utilisation of FLS radiography is unclear. This data reflects only MBS-reimbursed examinations, which as a direct result of the 2017 MBS changes no longer includes referrals made by chiropractors.[7, 32] Chiropractors are still able to order FLS X-rays, however they attract no MBS benefit, with the cost of the examination shifted to patients themselves or otherwise absorbed by the imaging service provider.[8] In their final report to the MBS review taskforce, the committee for medical imaging in low back pain argued that mechanisms which would effectively bypass the regulatory changes enacted by the MBS review taskforce could exist and should be closed to ensure the goals of the changes were met.[8] This could possibly include incorrect choice of

billing codes i.e. billing for a two-region spinal X-ray instead of a three or four region examination.[8] The existence of such loopholes may explain the increased volume of MBS-reimbursed two region spinal X-rays completed since FY2017-18[33], however these changes could also be consistent with population growth and a general trend of increased utilisation of diagnostic services. It would exceed the scope of this review to explore these mechanisms, however investigation is required to determine whether the taskforce's changes were effective in their goal of reducing unnecessary referrals for FLS radiography by chiropractors.[7]

Evidently, the issues outlined in this review are important and are worthy of consideration by both chiropractors and radiographers. There is both the scope and room for the two professions to work collaboratively in ensuring the clinically appropriate use of FLS radiography as a way of reducing unnecessary investigations and improving patient outcomes. The authors recognise the limitations of this scoping review process, namely a lack of critical review of the quality of evidence examined in the review and the broad scope in which the review was framed.[34] It is also acknowledged that the decision to limit eligibility to articles published between 2010 and 2021 lead to a substantial reduction in the volume of evidence which was able to be drawn upon. The strengths of this scoping review are in its broad scope, the comprehensive search strategy employed to identify current evidence and its satisfaction of its aims, which were principally to outline the various facets of FLS radiography use in chiropractic as it exists today. Further investigation is required to more definitively address this issue moving forward.

Conclusion

This review has identified a scarcity of literature addressing the completion of chiropractor referred FLS X-rays. Our review has outlined several pressing issues that warrant further investigation including a lack of quantitative measures to assess the utilisation of FLS X-rays by chiropractors, a lack of consensus of what constitutes appropriate clinical justification for imaging and the existence of a spectrum of beliefs amongst chiropractic authors about the clinical utility and limitations of FLS radiography. This provides radiographers with a definitive opportunity to demonstrate clinical leadership in this space and seek to begin a constructive dialogue with chiropractic referrers about the risks associated with unnecessary or unjustified spinal radiography. In doing this, diagnostic

radiographers as evidence-based health practitioners can actively contribute to the conversation surrounding the issues identified by this study and can be better positioned to advocate for the interests of the discipline and the safety of their patients.

Conflicts of Interest

No conflicts of interest are declared by the authors.

Funding sources

No funding was received for this project. Access to commercial databases was provided by the University of Sydney.

References

1. Adams J, Lauche R, Peng W, Steel A, Moore C, Amorin-Woods LG, et al. A workforce survey of Australian chiropractic: the profile and practice features of a nationally representative sample of 2,005 chiropractors. BMC Complementary and Alternative Medicine. 2017;17(1):14.
2. Young KJ, Bakkum BW, Siordia L. The Hangover: The Early and Lasting Effects of the Controversial Incorporation of X-Ray Technology into Chiropractic. Health and history. 2016;18(1):111-36.
3. Oakley PA, Harrison DE. American Chiropractic Association's Participation in Choosing Wisely: Close inspection shows no evidence to support its anti-imaging points 1 and 2. Asia-Pacific Chiropractic Journal. 2020;2.1(2).
4. Harrison DE, Oakley PA. Necessity for Biomechanical Evaluation of Posture, Alignment and Subluxation. Part I. The 6 Subluxations Types That Satisfy Nelson's Criterion for Valid Subluxation Theory. Journal of Contemporary Chiropractic. 2018;1(1):9-19.
5. Jenkins HJ, Downie AS, Moore CS, French SD. Current evidence for spinal X-ray use in the chiropractic profession: A narrative review. Chiropractic and Manual Therapies. 2018;26(1).
6. Chiropractic Board of Australia. Chiropractic diagnostic imaging: Chiropractic Board of Australia; 2019 [Available from: https://www.chiropracticboard.gov.au/Codes-guidelines/FAQ/Conduct-performance/Chiropractic-diagnostic-imaging.aspx.
7. Department of Health. Reducing unnecessary spinal x-rays 2017 [Available from: https://www1.health.gov.au/internet/main/publishing.nsf/Content/MBSR-reducing-unnecessary-spinal-x-rays.
8. Medicare Benefits Schedule Review Taskforce. First Report from the Diagnostic Imaging Clinical Committee - Low Back Pain. In: Health Do, editor. Canberra: Department of Health; 2016. p. 47-9.
9. Vom J, Williams I. Justification of radiographic examinations: What are the key issues? J Med Radiat Sci. 2017;64(3):212-9.
10. Jenkins HJ. Awareness of radiographic guidelines for low back pain: A survey of Australian chiropractors. Chiropractic and Manual Therapies. 2016;24(1).
11. Corso M, Cancelliere C, Mior S, Kumar V, Smith A, Cote P. The clinical utility of routine spinal radiographs by chiropractors: A rapid review of the literature. Chiropractic and Manual Therapies. 2020;28(1).
12. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Annals of internal medicine. 2018;169(7):467-73.
13. Sucharew H, Macaluso M. Progress notes: methods for research evidence synthesis: the scoping review approach. Journal of hospital medicine. 2019;14(7):416-8.
14. Alcantara J, Ohm J, Kunz D. The chiropractic care of children. The Journal of Alternative and Complementary Medicine. 2010;16(6):621-6.
15. Bussieres AE, Laurencelle L, Peterson C. Diagnostic Imaging Guidelines Implementation Study for Spinal Disorders: A Randomized Trial with Postal Follow-ups. Journal of Chiropractic Education. 2010;24(1):2-18.
16. Bussieres AE, Sales AE, Ramsay T, Hilles SM, Grimshaw JM. Impact of imaging guidelines on X-ray use among American provider network chiropractors: Interrupted time series analysis. Spine Journal. 2014;14(8):1501-9.

17. Bussières AEDCP, Sales AERNP, Ramsay TP, Hilles SDCMBA, Grimshaw JMMP. Practice Patterns in Spine Radiograph Utilization Among Doctors of Chiropractic Enrolled in a Provider Network Offering Complementary Care in the United States. Journal of manipulative and physiological therapeutics. 2013;36(3):127-42.
18. Coleman R, Wolf K, Lopes M, Coleman J. History or science: The controversy over chiropractic spinography. Chiropractic History. 2013;33(1):66-81.
19. Coleman RR, Lopes MA, Suttles RA. Computer modeling of selected projectional factors of the 84-in focal film distance anteroposterior full spine radiograph compared with 40-in focal film distance sectional views. Journal of Chiropractic Medicine. 2011;10(1):18-24.
20. De Carvalho D, Bussieres A, French SD, Wade D, Brake-Patten D, O'Keefe L, et al. Knowledge of and adherence to radiographic guidelines for low back pain: a survey of chiropractors in Newfoundland and Labrador, Canada. Chiropractic and Manual Therapies. 2021;29(1).
21. Johnson CD. X-ray Use in Chiropractic: Call for Papers. Journal of Chiropractic Humanities. 2019;26:1-2.
22. Simpson JK, Young KJ. Vitalism in contemporary chiropractic: a help or a hinderance? Chiropractic & Manual Therapies. 2020;28(1):35.
23. Walker BF, French SD, Page MJ, O'Connor DA, McKenzie JE, Beringer K, et al. Management of people with acute low-back pain: a survey of Australian chiropractors. Chiropractic & Manual Therapies. 2011;19(1):29.
24. Young KJ. Evaluation of publicly available documents to trace chiropractic technique systems that advocate radiography for subluxation analysis: A proposed genealogy. Journal of Chiropractic Humanities. 2014;21(1):1-24.
25. Young KJ. Gimme that old time religion: The influence of the healthcare belief system of chiropractic's early leaders on the development of x-ray imaging in the profession. Chiropractic and Manual Therapies. 2014;22(1).
26. Young KJ. Historical influence on the practice of chiropractic radiology: Part I - a survey of Diplomates of the American Chiropractic College of Radiology. Chiropractic & manual therapies. 2017;25:14-.
27. Young KJ. Historical influence on the practice of chiropractic radiology: part II - thematic analysis on the opinions of diplomates of the American Chiropractic College of Radiology about the future. Chiropractic & Manual Therapies. 2017;25(1):15.
28. Young KJ. A Tale of Specialization in 2 Professions: Comparing the Development of Radiology in Chiropractic and Medicine. Journal of chiropractic humanities. 2019;26:3-18.
29. Law M, Ma WK, Lau D, Chan E, Yip L, Lam W. Cumulative radiation exposure and associated cancer risk estimates for scoliosis patients: Impact of repetitive full spine radiography. Eur J Radiol. 2016;85(3):625-8.
30. Mogaadi M, Ben Omrane L, Hammou A. Effective dose for scoliosis patients undergoing full spine radiography. Radiation protection dosimetry. 2012;149(3):297-303.
31. Medical Radiation Practice Board of Australia. Professional capabilities for medical radiation practitioners. Medical Radiation Practice Board of Australia; 2020. p. 21.
32. Department of Health. Medicare Item Reports: 58108, 58115, 58120, 58121, 58126, 58127 (FY2015-16 FY 2020-21): Services Australia; 2021 [Available from: http://medicarestatistics.humanservices.gov.au/statistics/do.jsp?_PROGRAM=%2Fstatistics%2Fmbs_item_standard_report&DRILL=ag&group=58108%2C+58115%2C+58120%2C+58121%2C+58126%2C+58127&VAR=services&STAT=count&RP

T_FMT=by+time+period+and+state&PTYPE=finyear&START_DT=201507&END_DT=202104.

33. Department of Health. Medicare Item Reports: 58112, 58123 (FY2015-16 FY 2020-21) 2021 [Available from: http://medicarestatistics.humanservices.gov.au/statistics/do.jsp?_PROGRAM=%2Fstatistics%2Fmbs_item_standard_report&DRILL=ag&group=58123%2C+58112&VAR=services&STAT=count&RPT_FMT=by+time+period+and+state&PTYPE=finyear&START_DT=201007&END_DT=202106.

34. Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC Medical Research Methodology. 2018;18(1):143.

APPENDICES

Index of Appendices

Appendix A – Submission guidelines for authors (Journal of Medical Radiation Sciences)

Accessed online at:

https://onlinelibrary.wiley.com/page/journal/20513909/homepage/forauthors.html

1. MANUSCRIPT SUBMISSION

Thank you for your interest in *Journal of Medical Radiation Sciences* (*JMRS*). Please read the complete Author Guidelines carefully prior to submission, including the section on copyright. To ensure fast peer review and publication, manuscripts that do not adhere to the following instructions will be returned to the corresponding author for technical revision before undergoing peer review.

Note that submission implies that the content has not been published or submitted for publication elsewhere except as a brief abstract in the proceedings of a scientific meeting or symposium.

JMRS now offers Free Format submission for a simplified and streamlined submission process. Free Format submission allows researchers to submit their manuscript in their preferred formatting style at original submission. See details in Section 6. MANUSCRIPT PREPARATION.

Once you have prepared your submission in accordance with the Guidelines, manuscripts should be submitted online at **http://mc.manuscriptcentral.com/jmrs**

We look forward to your submission.

2. AIMS AND SCOPE

Journal of Medical Radiation Sciences (*JMRS*) is an international and multidisciplinary peer-reviewed journal that accepts manuscripts related to medical imaging/diagnostic radiography, radiation therapy, nuclear medicine, medical ultrasound/sonography, and the complementary disciplines of medical physics, radiology, radiation oncology, nursing, psychology and sociology. Manuscripts may take the form of: original articles, review articles, commentary articles, technical evaluations, case series and case studies.

JMRS promotes excellence in international medical radiation science by the publication of contemporary and advanced research that encourages the adoption of the best clinical, scientific and educational practices in international communities.

JMRS is the official professional Journal of the Australian Society of Medical Imaging and Radiation Therapy (ASMIRT) and the New Zealand Institute of Medical Radiation Technology (NZIMRT).

3. EDITORIAL REVIEW AND ACCEPTANCE

The acceptance criteria for all papers are the quality and originality of the research and its significance to our readership. All manuscripts are peer-reviewed and considered for publication by both an Editor and the Editor-in-Chief. Manuscripts may also be subject to additional statistical review. Final acceptance or rejection rests with the Editor-in-Chief, who reserves the right to refuse any material for publication.

Manuscripts should be written in a clear, concise, direct style. Where contributions are judged as acceptable for publication on the basis of content, the Editor-in-Chief and the Publisher reserve the right to modify typescripts to eliminate ambiguity and repetition and improve communication between the author and the reader.

Manuscripts may be reviewed by a statistical reviewer to consider (a) appropriateness of analysis to the research question and (b) presentation/interpretation of statistical results. This process can be initiated by the handling editor at initial submission or following suggestion by reviewers.

4. ETHICAL CONSIDERATIONS

Principles for Publication of Research Involving Human Subjects

All studies involving humans must be performed in accordance with the ethical standards laid down in an appropriate version of the Declaration of Helsinki (as revised in Brazil 2013), available at **http://www.wma.net/en/30publications/10policies/b3/index.html**. Manuscripts must contain a statement to the effect that all human studies have been reviewed by the appropriate ethics committee. It should also state clearly in the text that all persons gave their informed consent prior to their inclusion in

the study. Details that might disclose the identity of the subjects under the study should be omitted. Permission should be obtained from patients that are described in case studies or identifiable photographs. A statement that consent was obtained should appear in the published article.

Use of Animals in Research

Reports of animal experiments must state that the 'Principles of Laboratory Animal Care' (NIH Publication Vol 25, No. 28 revised 1996; http://grants.nih.gov/grants/guide/notice-files/not96-208.html) were followed, as well as specific national laws (e.g. the current version of the German Law on the Protection of Animals) where applicable.

Conflict of Interest

Authors must declare any financial support or relationships that may pose conflict of interest by disclosing at the time of submission any financial arrangements they have with a company whose product figures prominently in the submitted manuscript or with a company making a competing product. Such information will be held in confidence while the paper is under review and will not influence the editorial decision. If the article is accepted for publication, the Editor will usually discuss with the authors the manner in which such information is to be communicated to the reader.

Authorship and Acknowledgements

The journal adheres to the **definition of authorship set up by The International Committee of Medical Journal Editors (ICMJE).** The ICMJE recommends that authorship be based on the following 4 criteria: i) Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; ii) Drafting the work or revising it critically for important intellectual content; iii) Final approval of the version to be published; and iv) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Contributors who do not qualify as authors should be mentioned under 'Acknowledgements'. Authors are responsible for ensuring that this is correctly reported without any omission or non-qualified additions. Please include a statement defining each author's contribution in your covering letter.

Reproduction of Copyright Material

If excerpts from copyrighted works owned by third parties are included, credit must be shown in the contribution. It is the author's responsibility to also obtain written permission for reproduction from the copyright owners. For more information visit Wiley's Copyright Terms & Conditions FAQ at **http://exchanges.wiley.com/authors/faqs---copyright-terms--conditions_301.html**

Data Sharing and Data Accessibility

The journal encourages authors to share the data and other artefacts supporting the results in the paper by archiving it in an appropriate public repository. Authors should include a data accessibility statement, including a link to the repository they have used, in order that this statement can be published alongside their paper.

The Editors reserve the right to ask to examin the raw data on which the results of a submitted article are based.

Preprint Policy

Please find the Wiley preprint policy **here.**

This journal accepts articles previously published on preprint servers.

The *Journal of Medical Radiation Sciences* will consider for review articles previously available as preprints. Authors may also post the submitted version of a manuscript to a preprint server at any time. Authors are requested to update any pre-publication versions with a link to the final published article.

Publishing Ethics

This journal is a member of the **Committee on Publication Ethics** (COPE). Wiley's Publication Ethics Guidelines can be found at **http://exchanges.wiley.com/ethicsguidelines**. Note this journal uses iThenticate's CrossCheck software to detect instances of overlapping and similar text in submitted manuscripts.

5. MANUSCRIPT CATEGORIES

i. Original Articles
Word limit: 4000 words maximum including abstract and references
Abstract: 250 words maximum and must include subheadings (Introduction, Methods, Results, Conclusions)
References: In general, fewer than 30
Figures/tables: A combined total of 7 figures/tables maximum
Description: This category of paper should describe research studies including empirical studies, validated using statistical tests or qualitative methodologies and meta-analyses.

ii. Review Articles
Word limit: 5000 words maximum including abstract and references
Abstract: 250 words maximum, unstructured
References: No limit
Figures/tables: A combined total of 7 figures/tables maximum
Description: This category of paper includes narrative and systematic reviews. The aim of review articles is to provide an authoritative, comprehensive and up to date coverage on a relevant topic.

iii. ***Commentary***
Word limit: 2500 words maximum including abstract and references
Abstract: 250 words maximum, unstructured
References: No limit
Figures/tables: A combined total of 7 figures/tables maximum
Description: The aim of this category of paper is to discuss relevant aspects of a practice or an issue. Authors should review the literature pertaining to the topic and address the various perspectives that exist. Opinions and recommendations are then expressed with the support of evidence from the literature. Author(s) are requested to submit to the editors relevant educational and professional experiences as these will be considered prior to acceptance for publication

iv. ***Study Protocol***
Word limit: 2500 words maximum including abstract and references
Abstract: 250 words maximum, unstructured
References: No limit
Figures/tables: A combined total of 7 figures/tables maximum
Description:The aim of publishing study protocols is to inform readers of research projects that are proposed to commence or are ongoing. The study protocol must be a prospective cohort study design or a randomised controlled trial and must have full research ethics approval to be considered for publication. Authors should describe in detail the rationale behind the methodology of the study. The relevant sections of a paper as described under layout of paper should be included.

v. ***Technical Evaluation***
Word limit: 2500 words maximum including abstract and references
Abstract: 250 words maximum, unstructured
References: In general, fewer than 30
Figures/tables: A combined total of 7 figures/tables maximum
Description: An emerging technology or a new technique in medical radiation sciences.

vi. ***How to Do It***
Word limit: 2000 words maximum including abstract and references
Abstract: 250 words maximum, unstructured
References: In general, fewer than 30
Figures/tables: A combined total of 7 figures/tables maximum
Description: An educational article relevant to medical radiation sciences professionals.

vii. ***Case Study***
Word limit: 3000 words maximum including abstract and references
Abstract: 250 words maximum, unstructured
References: In general, fewer than 30
Figures/tables: A combined total of 7 figures/tables maximum
Description: This category of paper should describe one of the following:
• Previously unreported solution to a clinical problem.
• Previously unreported clinical condition or complication.

• Previously unreported interventional or radiation therapy technique in a recognised disease.
• Previously unreported, relevant imaging observations on recognised disease or lesion.

viii. ***Pictorial Review***
Word limit: 1500 words maximum including abstract and references
Abstract: 250 words maximum, unstructured
References: In general, fewer than 30
Figures/tables: A combined total of 15 figures/tables maximum
Description: The aim of a pictorial review is to provide an up-to-date visual portrayal of a topical issue, having particular educational value. The article may be based on a poster presentation at a major meeting.

ix. ***Editorials***
Word limit: 1500 words maximum
Abstract: No abstract required for this type of manuscript
Figures/tables: Maximum 1 figure or 1 table
References: 5 maximum
Description: An invited commentary on an article published in the same journal issue. Unsolicited proposals for Editorials may be submitted; however, in this case authors should only send an outline of the proposed paper for initial consideration.

x. ***Letters to the Editor***
Word limit: 500 words maximum including references
References: 5 maximum
Figures/tables: 1 maximum
Description: Letters to the Editor intended for publication may be submitted on any matters of interest to readers of *JMRS*. Letters commenting on recently published articles of JMRS are welcome but must be submitted within 2 months of publication of the article. The letter may be forwarded to the authors of that article to allow them to reply. If accepted, both letters will be published together. All authors of a letter must sign the letter.

xi. ***Book Reviews***
Word limit: 800–1000 words per book (equivalent to approximately 2 pages, single spaced)
Description: An in-depth critical review of the contents of the book and its **features.**

xii. ***Practice Guidelines***
Word limit: 5000 words maximum including abstract and references
Abstract: 250 words maximum, unstructured
References: No limit
A combined total of 7 figures/tables maximum
Description: Practice guidelines should be authored by members of non-profit groups or societies. It should describe how members were selected and how consensus was reached. The practice guideline must be supported by the best available evidence.

6. MANUSCRIPT PREPARATION

Reporting guideline

Authors should follow the appropriate **reporting guideline** and checklist for their study design: these are available through the EQUATOR network for (1) randomised controlled trials (**CONSORT**), (2) observational studies - cohort, case-control studies and cross-sectional studies (**STROBE**), (3) Systematic reviews (**PRISMA**) (4) case studies (**CARE**), (5) qualitative research (**COREQ**), (6) diagnostic prognostic studies (**STARD**), (7) quality improvement studies (**SQUIRE**), (8) study protocols (**SPIRIT**) and (9) clinical practice guidelines (**AGREE**).

Wiley Author Resources

Wiley have a range of resources for authors preparing manuscripts for submission available **here**. In particular, authors may benefit from referring to:

• **Editing, Translation and Formatting Support:** **Wiley Editing Services** greatly improves the chances of your manuscript being accepted. Offering expert help in English language editing, translation, manuscript formatting and figure preparation, Wiley Editing Services ensures that your manuscript is ready for submission.

• **Writing for Search Engine Optimization:** Optimize the search engine results for your paper, so people can find, read and ultimately cite your work. Simply read Wiley's **best practice SEO tips** – including information on making your title and abstract SEO-friendly, and choosing appropriate keywords.

Manuscript Style

JMRS now offers **Free Format submission** for a simplified submission process.

You will need the following to submit:

- Cover letter - contains an acknowledgment that all authors have contributed significantly and are in agreement with the content of the manuscript. In keeping with the authorship guidelines of the ICMJE, the contribution of each author should be specified.
- An anonymised version of your manuscript.
    - This should be an editable file (e.g. Word document). Text, figures and tables can be embedded into a single document or submitted in separate files – whichever you prefer.
    - Any information that may identify the authors should be anonymised.
    - All required sections should be contained in the manuscript, including abstract, introduction, methods, results, and conclusions.
    - Figures and tables should have legends. Figures should be the highest resolution possible.
    - References may be submitted in any style or format, as long as it is consistent throughout the manuscript. Note that the final format for references is the Vancouver system.
    - Supporting information should be submitted in separate files.
    - If the manuscript, figures or tables are difficult for you to read, they will also be difficult for the editors and reviewers, and the editorial office will send it back to you for revision without review.
    - Your manuscript may also be sent back to you for revision without review if the quality of English language is poor.
- An ORCID ID, freely available at https://orcid.org.
- A separate title page that includes the following:
    - Manuscript title.
    - Your co-author details, including affiliations and email addresses.
    - Statements relating to our ethics and integrity policies, which may include any of the following*:*
- data availability statement
- funding statement
- conflict of interest disclosure
- ethics approval statement
- patient consent statement
- permission to reproduce material from other sources
- clinical trial registration

To submit, login at **http://mc.manuscriptcentral.com/jmrs** and create a new submission. Follow the submission steps as required and submit the manuscript.

If you are invited to revise your manuscript after peer review, the journal will also request the revised manuscript to be formatted according to journal requirements as described below.

7. FORMATTING FOR REVISED MANUSCRIPT

The main text of the manuscript should be presented in the following order:
(i) Text;
(ii) References;
(iii) Tables (each table complete with title and footnotes);
(iv) Figure legends.

Main text. The main text should be prepared using Microsoft Word, doubled-spaced. All lines should be numbered. All pages should be numbered consecutively in the top right-hand corner, beginning with the first page. **Word limits need to be adhered to.**

Spelling. Spelling should follow one of the Australasian conventions and must be consistent throughout the manuscript.

Abbreviations. In general, terms should not be abbreviated unless they are used repeatedly and the abbreviation is helpful to the reader. Initially use the word in full, followed by the abbreviation in parentheses. Thereafter use the abbreviation only.

Acknowledgments

The contribution of colleagues or institutions should also be acknowledged. Personal thanks and thanks to anonymous reviewers are not appropriate.

Abstract and Keywords

All articles should have an abstract not exceeding 250 words. In the case of original research articles the abstract must be structured using the following headings: Introduction (including purpose of the study); Methods; Results; and Conclusions. The abstract should not contain references.

Five key words, for the purposes of indexing, should be supplied below the abstract, in alphabetical order, and should be taken from those recommended by the US National Library of Medicine's Medical Subject Headings (MeSH) browser list at **http://www.nlm.nih.gov/mesh/meshhome.html**.

References

This journal uses the Vancouver reference style; as the journal offers Free Format submission, however, this is for information only and you do not need to format the references in your article. This will instead be taken care of by the typesetter.

Tables

Tables should be on a separate page with the legend above. Number tables consecutively in the text in Arabic numerals. The table, legend and footnotes must be understandable without reference to the text. Vertical lines should not be used to separate columns. Column headings should be brief, with units of measurement in parentheses; all abbreviations must be defined in footnotes. Footnote symbols: †, ‡, §, ¶ should be used (in that order) and *, **, *** should be reserved for *P*-values. Statistical measures such as SD or SEM should be identified in the headings.

Figure legends

Type figure legends on a separate page. Legends should be concise but comprehensive – the figure and its legend must be understandable without reference to the text. Include definitions of any symbols used and define/explain all abbreviations and units of measurement.

Figures

Upload figures as separate files with the figure number in the file name. Although authors are encouraged to send the highest-quality figures possible, a wide variety of formats, sizes, and resolutions are accepted.

Click here for the basic figure requirements for figures submitted with manuscripts.

Supporting Information

Supporting information is information that is not essential to the article, but provides greater depth and background. It is hosted online and appears without editing or typesetting. It may include tables, figures, videos, datasets, etc.

Click here for Wiley's FAQs on supporting information.

Note: if data, scripts, or other artefacts used to generate the analyses presented in the paper are available via a publicly available data repository, authors should include a reference to the location of the material within their paper.

8. COPYRIGHT AND OPEN ACCESS LICENCING

Authors publishing in *JMRS* retain copyright in their article.

If your paper is accepted, the author identified as the formal corresponding author for the paper will receive an email prompting them to login into Author Services; where via the Wiley Author Licensing Service (WALS) they will be need to complete a license agreement on behalf of all authors on the paper.

The following license agreements are available:

- Creative Commons Attribution (CC-BY) license
- Creative Commons Attribution Non-Commercial (CC-BY-NC) license
- Creative Commons Attribution-Non-Commercial-NoDerivs (CC-BY-NC-ND) license

RCUK or Wellcome trust funded authors will be directed to sign the open access agreement under the terms of the Creative Commons Attribution (CC-BY) license in order to be funder compliant.

JMRS does not charge any submission fees. To find out more about the journal's Article Publication Charges, including waivers for ASMIRT and NZIMRT members, **click here**.

For more information on the terms and conditions of these licenses, please visit: **http://www.wileyopenaccess.com/details/content/12f25db4c87/Copyright--License.html**

9. PUBLICATION PROCESS AFTER ACCEPTANCE

Accepted article received in production

When your accepted article is received by Wiley's production production team, you (corresponding authors) will receive an email asking you to login or register with **Author Services.** You will be asked to sign a publication licence at this point.

Proofs

Once your paper is typeset you will receive email notification of the URL from where to download a PDF typeset page proof, associated forms and full instructions on how to correct and return the file. Please note that you are responsible for all statements made in your work, including changes made during the editorial process and thus you must check your proofs carefully. Note that proofs should be returned 48 hours from receipt of first proof.

Early View

The journal offers rapid speed to publication via Wiley's Early View service. **Early View** (Online Version of Record) articles are published on Wiley Online Library before inclusion in an issue. Note there may be a delay after corrections are received before your article appears online, as Editors also need to review proofs. Once your article is published on Early View no further changes to your article are possible. Your Early View article is fully citable and carries an online publication date and DOI for citations.

10. POST PUBLICATION

Offprints

A PDF reprint of the article will be supplied free of charge to the corresponding author. Additional printed offprints may be ordered online for a fee. Please click on the following link and fill in the necessary details and ensure that you type information in all of the required fields: **http://offprint.cosprinters.com/cos**. If you have queries about offprints please e-mail: **offprint@cosprinters.com**.

Promoting your paper

Now is the time to start promoting your article. Find out how to do that **here.**

Video abstracts

Extend the reach and visibility of your research by creating a video abstract or video byte. For a fee, Wiley—in partnership with Research Square—offers you the opportunity to outline the key findings of your published article in a dynamic video. Through this multimedia content, colleagues, funders and anyone else interested in your work can experience your research anytime, anywhere. **Find out more here**.

Measuring the impact of your work

Wiley also helps you measure the impact of your research through our specialist partnerships with **Kudos** and **Altmetric.**

Authorship Changes

In accordance with **Wiley's Best Practice Guidelines on Research Integrity and Publishing Ethics** and the **Committee on Publication Ethics' guidance**, this journal will allow authors to correct authorship on a submitted, accepted, or published article if a valid reason exists to do so. All authors – including those to be added or removed – must agree to any proposed change. To request a change to the author list, please complete the **Request for Changes to a Journal Article Author List Form** and contact either the journal's editorial or production office, depending on the status of the article. Authorship changes will not be considered without a fully completed Author Change form. [Correcting the authorship is different from changing an author's name; the relevant policy for that can be found in **Wiley's Best Practice Guidelines** under "Author name changes after publication."]

Wiley's Author Name Change Policy

In cases where authors wish to change their name following publication, Wiley will update and republish the paper and redeliver the updated metadata to indexing services. Our editorial and production teams will use discretion in recognising that name changes may be of a sensitive and private nature for various reasons including (but not limited to) alignment with gender identity, or as a result of marriage, divorce, or religious conversion. Accordingly, to protect the author's privacy, we will not publish a correction notice to the paper, and we will not notify co-authors of the change. Authors should contact the journal's Editorial Office with their name change request.

11. CONTACT DETAILS

Please direct any questions regarding submission and peer review to the Editorial Assistant at **JMRS.eo@wiley.com**

Author Guidelines updated 29 March 2021

Appendix B – Completed PRISMA-ScR Checklist

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	p4-5
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	p6 Unstructured as per submission guidelines
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	p7
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	p7
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	p7-8
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	p8
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	p7-8, 23
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	p23
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	p8
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	p8
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	p8
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	N/A
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	p8

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	p8-9
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	p23-25
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	N/A
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	p23-25
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	p23-25
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	p9-16,
Limitations	20	Discuss the limitations of the scoping review process.	p16
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	p16
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	p16

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.
* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.
† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).
‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.
§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. doi: 10.7326/M18-0850.

Appendix C – Search strategy

Search Terms	**Concept 1:** Chiropractors and the management of spinal disease	**Concept 2:** X-Rays and Diagnostic Imaging
	Chiropract*, Chiropractic, Manipulat*, Manipulative therap*, Spine*, Spinal manipulation	X-ray*, Xray*, Diagnostic radiograph*, Radiography*, Diagnostic imaging
Databases	AMED via Ovid®, EMBASE via Ovid®, MedLine via Ovid®, Scopus	
Inclusion Criteria	Peer-reviewed titles, literature reviews and primary studies, position statements from regulatory or professional bodies, government publications and reports Articles investigating the indications for, referral patterns and utilisation of full-length spinal X-Rays by chiropractors, defined as an anteroposterior or lateral radiograph of the cervical, thoracic, lumbar and/or the sacral spine	
Exclusion Criteria	Opinion pieces, letters to the editor Articles investigating the utilisation of diagnostic radiography by health practitioners other than chiropractors Articles investigating the utilisation of diagnostic radiography by chiropractors for regions of the body other than the full-length of the spine Articles investigating the utilisation of imaging modalities other than plain-film radiography Small cohort or case studies Articles where conflicts of interest were declared by the authors Articles published in a language other than English	
Timeframe	The scoping review was conducted in April 2021. A forward and backwards citation search of literature identified in the review was performed in September 2021 to identify missed articles. Search results were limited to articles published between 2010 and 2021 to ensure currency of evidence and relevance to contemporary practice.	

Appendix D – Search histories and results (AMED, EMBASE, MedLine and Scopus)

AMED

#	Searches	Results
1	chiropract*.mp. [mp=abstract, heading words, title]	8237
2	spinal manipulation*.mp [mp=abstract, heading words, title]	1153
3	x-ray*.mp. [mp=abstract, heading words, title]	2594
4	xray*.mp. [mp=abstract, heading words, title]	5
5	diagnostic imaging.mp. [mp=abstract, heading words, title]	1924
6	radiograph*.mp. [mp=abstract, heading words, title]	5120
7	1 or 2	8927
8	3 or 4 or 5 or 6	8523
9	7 and 8	492
10	limit 9 to yr=”2010 -Current”	38
	Total	**38**

EMBASE

#	Searches	Results
1	chiropractic/ or chiropract*.mp.	8571
2	spinal manipulation.mp. or spine manipulation/	1988
3	radiography/ or X ray/ or x-ray*.mp.	971,232
4	xray.mp.	4744
5	diagnostic imaging.mp. or diagnostic imaging/	213,418
6	1 or 2	9767
7	3 or 4 or 5	1,162,341
8	6 and 7	531
9	limit 8 to yr=”2010 -Current”	205
	Total	**205**

MedLine

#	Searches	Results
1	Manipulation, Chiropractic/ or Chiropractic/ or chiropract*.mp.	7380
2	x-ray*.mp or Radiography/	1,155,180
3	diagnostic imaging.mp. or Diagnostic Imaging/	1,281,048
4	2 or 3	1,851,525
5	1 and 4	587
6	limit 5 to yr=”2010 -Current”	175
	Total	**175**

Scopus

#	Search terms	Results
1	(TITLE-ABS-KEY (chiropract* OR “spinal manipulation”) AND TITLE-ABS-KEY (x-ray* OR xray* OR radiography OR “diagnostic imaging”)) AND PUBYEAR >2009)	368
	Total	**368**

Appendix E – Draft proof of the version of this manuscript previously submitted to the Journal of Medical Radiation Sciences for peer-review

Journal of Medical Radiation Sciences
Open Access

Factors Effecting Chiropractor-Referred Requests for Full-length Spinal Radiographic Examinations: A Scoping Review

Journal:	*Journal of Medical Radiation Sciences*
Manuscript ID	Draft
Wiley - Manuscript type:	Review Article
Discipline:	Medical Imaging, Radiology, General
Clinical Site:	Skeletal/Bones
Key Words:	Research - review < General, General Radiography < Medical Imaging, Radiographer < Medical Imaging, Interprofessional / Multidisciplinary < General, Trends < General
Abstract:	Chiropractors often refer their patients for full-length (three to four region) radiographs of the spine as part of their clinical assessment, which are frequently completed by radiographers in medical imaging practices. Overuse of spinal radiography by chiropractors has previously been reported and remains a contentious issue. Our review examined this issue in the context of evidence-based practice in medical imaging. A search of four databases (AMED, EMBASE, MedLine and Scopus) and a hand search of Google and Google Scholar was conducted using key words. Articles were screened against an inclusion/exclusion criterion for relevance to research questions. Themes and findings were extracted from eligible articles and evidence was synthesised using a narrative approach. 34 eligible articles were identified. Five themes were extracted, and conclusions drawn by authors were charted to identify confluent findings. We identified a paucity of literature addressing this issue and an underrepresentation of relevant perspectives from medical radiation practitioners. The review identified issues which could impact upon the monitoring of the utilisation of spinal radiography for adherence to regulatory guidelines by chiropractors including inconsistencies between published guidelines and techniques, an absence of quantitative metric for the utilisation of spinal radiography in chiropractic and the conflation of terms specific to chiropractic and conventional medical terminology which could make it difficult for radiographers to assess clinical justification. Further investigation is required to further understand the impacts of the completion of full-length spinal X-rays requested by chiropractors by medical imaging practices and the alignment of this practice with current evidence.
Note: The following files were submitted by the author for peer review, but cannot be converted to PDF. You must view these files (e.g. movies) online.	
JMRS Sub Evidence Library.enl	

Factors Effecting Chiropractor-Referred Requests for Full-length Spinal Radiographic Examinations: A Scoping Review

Abstract

Australian chiropractors often refer their patients for full-length (three to four region) radiographs of the spine as part of their clinical assessment, which are frequently completed by radiographers in medical imaging practices. Overuse of spinal radiography by chiropractors has previously been reported and remains a contentious issue. Our review examined this issue in the context of evidence-based practice in medical imaging. A search of four databases (AMED, EMBASE, MedLine and Scopus) and a hand search of Google and Google Scholar was conducted using key words. Articles were screened against an inclusion/exclusion criterion for relevance to research questions. Themes and findings were extracted from eligible articles and evidence was synthesised using a narrative approach. A total of 34 eligible articles were identified. Five themes were extracted, and conclusions drawn by authors were charted to identify confluent findings. We identified a paucity of literature addressing this issue and an underrepresentation of relevant perspectives from medical radiation practitioners. The review identified issues which could impact upon the monitoring of the utilisation of spinal radiography for adherence to regulatory guidelines by chiropractors including inconsistencies between published guidelines and techniques, an absence of quantitative metrics for the utilisation of spinal radiography in chiropractic and the conflation of terms specific to chiropractic and conventional medical terminology which could make it difficult for radiographers to assess clinical justification. Further investigation is required to further understand the context and impacts of the completion of full-length spinal X-rays requested by chiropractors by medical imaging practices and the alignment of this practice with current evidence.

Keywords: chiropractic, diagnostic radiography, full-length spinal X-ray

Introduction

Chiropractors are practitioners who perform manual therapies to treat a myriad of health conditions.[1-3] Among the core beliefs of chiropractic is that peripheral ailments of various aetiology are the result of a blockage of the body's innate energy, caused by minute misalignments of the spinal column termed 'subluxations'[1-3], which can be treated through manual adjustment. Beliefs such as this, which appear not supported by contemporary scientific understanding of physiology[2], have relegated the perception of chiropractic to the periphery of the mainstream medical establishment and the larger Australian health care system.[4, 5] Despite this, chiropractic remains a prominent health profession in Australia, with a substantial client base in the community, capturing a large market share of health expenditure nationally.[4-6] As registered health practitioners, Australian chiropractors can refer their patients for diagnostic investigations, including radiological studies, based on different clinical indications.[7-9] Frequently, chiropractors refer patients to medical imaging practices for full-length spinal (FLS) X-rays, to assess for underlying pathological and structural changes which may impact upon their treatment.[10] Between 2014 and 2015, approximately 130,000 three-to-four region spinal X-rays were performed in Australia.[11, 12] Most were requested by chiropractors.[11]

The acceptance of these referrals by medical imaging practices remains a contentious issue amongst medical radiation practitioners (MRP's), and indeed chiropractors, with different authors advocating for both frequent or infrequent utilisation of spinal radiography in practice.[13] Additionally, there is limited evidence to suggest that routine radiography of the spine confers any benefit to patients or otherwise reduces risk to patient or practitioner.[10, 14] In medical imaging practices, MRP's are charged with assessing the clinical justification for medical imaging in the context of the known risks of exposure to ionising radiation and determining if a given examination is clinically necessary.[15-17] Therefore, the lack of apparent evidence surrounding the utility of FLS X-rays in chiropractic presents a challenge to the foundations of evidence-based practice and should be considered an important issue for radiographers and radiologists alike.[16] It is evident that the completion of FLS X-rays requested by chiropractors in the medical imaging practices is a multifaceted issue with multiple stakeholders and perspectives, and as such initial reporting and investigation lends itself to a scoping review approach.[18] The aim of this scoping review was to examine the issue of the referral for and utilisation of full-length spinal radiographs by chiropractors in the

context of evidence-based practice in medical imaging and outline what is known and unknown in published literature.

Methods

Protocol

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses - Scoping review extension (PRISMA-ScR) checklist was used for this review.[19]

Search Strategy

The search strategy used for this review was adapted from that outlined by the Joanna Briggs Institute's protocol for scoping reviews.[19] An initial search was conducted using variations of the keywords "chiropractic", "spinal manipulation" and "X-ray" in four databases; AMED, EMBASE, Medline and Scopus. A hand search of Google and Google Scholar was conducted using the same parameters to identify potential missed articles and grey literature. Titles and abstracts were then reviewed for eligibility by the authors, followed by a full-text review.

Eligibility Criteria

Articles were included if they investigated spinal X-ray utilisation by chiropractors as a routine practice or otherwise alluded to specific indications for imaging. Position statements from regulatory and professional bodies were included in data synthesis. To reflect current attitudes and knowledge, articles published between 2010 and 2021 were eligible for inclusion. Papers reporting utilisation of FLS X-rays by practitioners of disciplines other than chiropractic, case reports, opinion pieces and articles where conflicts of interest which could be seen to impact the validity of findings were declared by authors were excluded.

Data Charting Process

Data were charted according to their alignment with key themes identified during an analysis of eligible references. Conclusions drawn by authors in the context of these themes were extrapolated and charted in MS Excel to assess the prevalence of opinions or themes amongst the current literature surrounding this issue.

Evidence Synthesis

Conclusions drawn by authors were explored and described in the context of the themes extrapolated during the full-text review of eligible articles. Issues surrounding the utilisation of full-length spinal X-rays by chiropractors were examined and gaps in knowledge were described through a narrative approach.

Results

A total of 786 records were identified in the initial database search. After removing duplicates, 471 titles and abstracts were screened, with 71 full text papers assessed for eligibility. An additional 13 papers were identified through hand searches of Google and Google Scholar. In total, 34 papers were included in the review (Figure 1).

~ Please insert Figure 1 here ~

Study Characteristics

A total of 18 of the 34 eligible articles were authored by researchers with a professional background in chiropractic. Except for a series of articles published by an author with a background in both chiropractic and radiography[1-3], we could find no articles which directly addressed the issue of the completion of chiropractor requested FLS X-ray examinations by medical imaging practices. A comprehensive breakdown of the characteristics of studies included in this review are outlined in Table 1.

Thematic Extraction

Five confluent themes were present throughout the reviewed articles; the integration and clinical utility of spinal radiography into chiropractic practice, regulation of spinal X-ray utilisation by chiropractors, alternatives to spinal radiography in chiropractic, risks associated with spinal radiography and the use of ionising radiation, and the implementation of evidence-based practice (EBP) by radiographers during the screening of referrals for imaging.

The integration and clinical utility of spinal radiography in chiropractic practice

A total of 20 of the 34 eligible articles reported findings related to the integration and clinical utility of spinal radiography. [1-3, 6, 10, 13, 14, 20-33] Articles

described either the historical integration of X-rays into chiropractic stemming from both the inception of chiropractic and radiography[1-3, 27] or described chiropractic techniques and treatment systems and the role of full-length spinal X-rays as a diagnostic tool.[1, 3, 10] Authors suggested a direct lineage between the founding of chiropractic and radiography, evidenced by the early adoption of X-rays into chiropractic practice as a means of supporting the claims made by its founders.[1, 3] There was a lack of quantitative measures described to assess the actual utilisation of diagnostic radiography in general by chiropractors. Rather, conclusions about utilisation were only able to be drawn from cross-sectional cohort studies with relatively small sample sizes.[6, 14, 26, 32] This represents a gap in the current knowledge surrounding this issue.

The regulation of spinal X-ray utilisation by chiropractors

Seven eligible articles were identified which addressed this theme or described frameworks, guidelines or the legal regulation of the use of spinal X-rays by chiropractors.[10, 14, 22, 24, 26, 29, 31] Authors described indications and contraindications for imaging based on different clinical presentations.[10, 14] Two cohort studies were identified, which investigated the awareness of, and adherence to radiographic guidelines surrounding the use of spinal radiography in patients presenting with low back pain to chiropractors in Australia and Canada[14, 29]. Both studies found that only approximately half of respondents were aware of the guidelines which define low back pain as a contraindication for imaging[14, 29], with one study reporting that 21% of respondents believed that FLS X-ray was warranted for the investigation of low back pain. [29] This belief is at odds with current evidence, which suggests that plain-film imaging of the spine has limited clinical utility for the management of non-traumatic low-back pain.[10, 11, 14, 28] This finding suggests a low adherence to established imaging guidelines amongst chiropractic practitioners. There were also variations in the terminology and nomenclature used to justify the need for FLS X-rays by chiropractors and some authors conflated interpretations of terms which were specific to chiropractic (namely ‘subluxation’) with terms that are specific to common spinal pathologies.[1, 3, 28]

Alternatives to spinal radiography in chiropractic

Three authors concluded that FLS X-ray imaging of the spine is contraindicated for common chiropractic presentations such as low back pain[10, 14, 29] or where clinical suspicion exists for spinal pathology.[10, 14, 23, 33] Authors also concluded that CT or MRI examinations are more sensitive and appropriate for the diagnosis and management of these presentations.[10, 14, 28, 29]

Risks associated with spinal radiography and the use of ionising radiation

There was a spectrum of conclusions drawn between authors who addressed the risks of radiation exposure from FLS radiography. Some authors advocated strongly for conservative utilisation on the grounds of risks posed to from ionising radiation exposure[25, 28, 29, 33], whereas other authors argued that these risks did not always outweigh the potential benefits of FLS radiography in chiropractic practice[10]; a consideration that the authors also argued needed to be made by the referring practitioners.[10, 14] A comprehensive breakdown of the different conclusions authors came to with regards to the risk radiation exposure from spinal radiographic examinations carries is included as Table 2.

The implementation of EBP by radiographers during the screening of referrals for imaging made by chiropractors

Evidence-based practice is a construct in which clinical decision-making is informed by up-to-date evidence and input from consumers to ensure patients receive high quality health care and are afforded positive health outcomes from treatment.[16] Its importance and criticality in practice is underscored by the dynamic nature of medical research, and its impacts on existing practices.[16, 34] Articles which addressed this theme examined the role of evidence-based practice in radiography, ways in which it is exercised by radiographers or barriers to its implementation. There was a lack of crossover between other themes identified through this review and articles which addressed the theme of the implementation of evidence-based practice by radiographers when screening referrals for imaging.[15, 16] In one instance, a chiropractic author referred to chiropractors who perform their own radiography as ‘radiographers’ and made some reference to evidence-based practices from a

chiropractic perspective[27], but no other instance of the use of this nomenclature in other articles was found. While authors addressed the broader issue of barriers to the screening of referrals made by health practitioners in a general sense[15], and suggested potential barriers to knowledge translation in radiographic practice, no literature which specifically addressed the screening of chiropractic referrals for imaging in the medical imaging practice setting was found.

~ Please insert Tables 1 and 2 here ~

Discussion

Full-length spinal X-Rays and chiropractic

In keeping with the belief that subluxations of the vertebrae are responsible for peripheral disease, chiropractors have historically used spinal radiography to "detect" subluxations so that they can apply targeted manual therapy interventions.[1, 3, 27, 28, 31, 35] This notion was genealogically traced to the works of BJ Palmer; the son of the patriarch of chiropractic D.D. Palmer, who founded the discipline in 1895 in a 2014 review of publicly available documents.[36] The review argued that BJ Palmer advocated for the use of spinal radiography (termed "spinography") to prove the existence of subluxations. In the time between chiropractic's founding and its apparent renaissance today, subluxation as defined by D.D. and BJ Palmer is yet to be proven experimentally.[1, 27] Therefore, the utilisation of plain-film radiographs to identify Palmer subluxations is not aligned with the principles of evidence-based practice.[1, 2, 16, 27, 37]

It remains unclear how prevalent beliefs in Palmer subluxations is amongst chiropractic practitioners today, with many published chiropractic treatment techniques citing clinical suspicion of subluxation by both Palmer's definition and definitions adopted in mainstream medicine as grounds for referrals for full-length spinal X-rays.[1, 10] Chiropractors who believe Palmer's interpretation of subluxation as the root cause of nearly all disease and furthermore believe that they can be seen on plain-film radiographs are dubbed "straights" among the chiropractic community and are thought to be a minority group today.[3] However, a review of chiropractic technique systems that advocate for the use of spinal X-rays identified six techniques which are used by both "straight chiropractors" and "mixers" (chiropractors who incorporate and believe in evidence-based modern medical and physiological conventions) which require or otherwise prescribe the use of full-length spinal

radiographs: the *Applied Spinal Biomechanical Engineering, Gonstead, Universal Chiropractic College and Aquarian Age Healing, Pierce/Sullivan, Spinal Stressology* and *Chiropractic BioPhysics (CBP)* techniques.[1] This finding points to a potential obfuscation between the beliefs of straight and mixer chiropractors and the verbiage used to justify referrals for medical imaging, which could impact on the ability of medical radiation practitioners to assess the clinical justification of referrals for imaging they receive.

Beyond the search for radiographic appearances of subluxations, chiropractic authors still broadly contend that there are definitive grounds for referrals for routine spinal radiography. In one capacity, full-length spinal radiographs are used by chiropractors to screen for so-called 'red flags'.[10, 28, 31] These red flags are radiological indications of disease which would otherwise be a contraindication for the type of manual therapies utilised in chiropractic, or a pathological process where the prescribed treatment would exceed the scope of practice of a chiropractor.[10, 28] However, a narrative review of evidence for the use of spinal X-ray by chiropractors found that the utilisation of full-length spinal X-rays as a routine screening measure is not founded in evidence, as plain-film spinal radiography lacks the sensitivity required for accurate diagnosis of many common spinal pathologies, including those often cited as red flags by chiropractors.[10]

The evidence presented in the articles which address the theme of the use of full-length spinal radiography in chiropractic point to the existence of a spectrum of beliefs, clinical knowledge and terminology employed by chiropractors to justify requests for diagnostic imaging.[13, 14, 24, 29] While guidelines exist to steer practitioners away from referring patients for unnecessary or contraindicated radiographic investigations, evidence suggests that these are not universally adopted or adhered to by practitioners.[7, 9, 11, 14, 24, 26, 29] In a survey of 480 Australian chiropractors conducted in 2016, it was found that only half of respondents were aware of the current guidelines surrounding the use of imaging in the treatment of low back pain.[14] A similar cross-sectional study published in 2021 found that a small proportion of respondents (~21%) believed that low back pain alone was an indication for FLS radiography[29]; a notion which is at odds with current imaging guidelines for the investigation of low back pain.[29] Further investigation is required to understand the impact that this reported incongruity in clinical justification and adherence to published guidelines for imaging has upon referral patterns of chiropractors requesting FLS X-rays.

Regulation of Chiropractic Referrals for Spinal Radiography

In 2017, in response to an apparent over-utilisation of full-length spinal X-rays by referring chiropractors that was identified during a review of compensation rates for diagnostic investigations, the Australian Medicare Review Taskforce changed the Medicare Benefits Schedule (MBS) for chiropractor-referred spinal X-rays to exclude three to four-region spinal examinations from reimbursement.[11] This change was ostensibly made to deter chiropractors from referring their patients for these kinds of examinations by shifting the cost-burden from Medicare to the patients themselves.[11] The efficacy of this change remains unreported in literature. Referrals for FLS X-rays appear still made by chiropractors and completed by medical imaging practices with the cost of the examination shifted to patients, in lieu of MBS reimbursement. The rate at which this is occurring in imaging practices is not currently reportable and thus the information is not in the public domain.[38] While currently available MBS data shows a significant reduction in the number of FLS X-ray examinations requested by health practitioners after the changes to the MBS were made (see Figure 2), without the inclusion of chiropractic referrals for imaging in the MBS reimbursement schedule, the data is no longer representative of the true number of FLS X-ray examinations being performed.

~ Please insert Figure 2 here ~

A cross-sectional study published in 2016 found that 74.8% of Australian chiropractors refer their patients for imaging by external providers.[14] However, Australian chiropractors can also own and operate their own radiographic equipment.[7, 8] While practitioners may keep a record of radiographic examinations they have completed using their X-ray equipment for medicolegal and for adherence to accreditation standards[38], there is currently no established mechanism for reporting of X-ray usage by chiropractors in their private practices.[38] This represents another unknown variable in the quantitative assessment of the current utilisation of FLS X-rays by chiropractors.

Risks Associated with Spinal Radiography

There are inherent risks associated with exposing patients to ionising radiation; as utilised in FLS X-rays, that are well-reported in literature.[10, 22, 28] Ionising radiation in the

form of X-rays, used to generate spinal radiographs are known to stimulate biochemical reactions in the body that have the potential to induce stochastic effects of radiation exposure, and at higher intervals, deterministic biological effects. At 'diagnostic levels' of radiation exposure used in diagnostic imaging, the stochastic effects of exposure; namely cancer remain the preeminent threat to patient safety, which radiographers are charged with moderating[15], just as referring practitioners are charged with assessing whether the risks of the examination outweigh its clinical utility.[10, 13, 15] Therefore, the completion of unjustified or unnecessary radiographic examinations is at odds with the guiding principles of radiation safety, and undermines the capacity of medical radiation practitioners to deliver evidence-based healthcare.[15]

Evidence-based Practice and Chiropractic Referrals for Diagnostic Radiography

Diagnostic radiographers, as stewards of radiation safety and health professionals are charged with the delivery of safe, timely and evidence-based care for patients requiring diagnostic imaging services. Central to this responsibility, is the duty of ensuring exposure to radiation for the purposes of diagnostic imaging are minimised, optimised and justified to moderate the known risks of exposure to ionising radiation.[15, 16] One aspect of this is the screening of referrals for diagnostic imaging made by other providers for appropriateness in the context of the clinical information available to the radiographer.[15] In the context of the known risks of exposure to ionising radiation, MRP's must weigh the risks and benefits of imaging, by assessing the clinical justification of referrals.[15, 16] This can include referrals made by chiropractors for FLS radiography. In the setting of a medical imaging practices, this responsibility is shared between radiographers and radiologists[15, 16]. Barriers to radiographer's abilities to assess whether justification for radiographic investigation exists on the basis of referral information have been described, with medical dominance[15], difficulties in knowledge translation[34] and differences in education being potential causes for a radiographer's ability to assess the justification of radiographic examinations.[15] This in itself is an issue worth investigating further in the context of chiropractic referrals for medical imaging.

Therefore, in the context of the described lack of evidence for the continued use of routine spinal radiography in chiropractic[10] and the apparent lack of consensus amongst chiropractic authors about what constitutes sufficient clinical justification for full-length

spinal radiography[13], consideration must be given by practitioners to the notion that the continued acceptance of chiropractic referrals for FLS X-rays by MRP's may not be aligned with the principles of evidence-based practice.[16] In completing these examinations, requested by chiropractors, that potentially lack justification, MRP's are potentially compromising patient safety through the abandonment of the core principles of radiation safety and undermining their position as evidence-based practioners.[15] Further investigation is required to understand the extent of the issues identified in this study and build upon the work that has already been done. We recognise the limitations of the scoping review process as outlined by other authors[18] and acknowledge that evidence exists outside of the time limits we imposed to ensure currency in the literature we reviewed. Additionally, the reported lack of quantitative measures available to reviewers to assess the utilisation of full-length spinal X-rays by chiropractors remains a hurdle to comprehension of the scope of the issue as it exists today. More evidence is required to understand the depth of this issue and make headway in understanding its impacts for both patients and practitioners.

Conclusion

Our review has identified a definitive scarcity in literature addressing the completion of chiropractor referred FLS X-rays by medical imaging practices. There is a lack of relevant perspectives from key stakeholders, namely medical radiation practitioners and a relative overrepresentation of literature authored by chiropractic practitioners. Our review has outlined several pressing issues that warrant further investigation including a lack of quantitative measures to assess the utilisation of FLS X-rays by chiropractors, a lack of evidence to support its continued use as a screening or diagnostic measure by chiropractors, a lack of consensus of what constitutes appropriate clinical justification for imaging and the conflation of chiropractic and medical terminology which could conceivably impact on a medical radiation practitioner's ability to assess the clinical justification for referrals made by chiropractors. We believe that there is an urgent need for further investigation addressing the professional attitudes of radiographers who are charged with completing these examinations, to understand the impacts of this issue in contemporary radiographic practice. In doing this, diagnostic radiographers as evidence-based health practitioners can actively contribute to the conversation surrounding the issues identified by this study and can be better positioned to advocate for the interests of the discipline and the safety of their patients.

Conflicts of Interest

No conflicts of interest are declared by the authors.

References

1. Young KJ. Evaluation of publicly available documents to trace chiropractic technique systems that advocate radiography for subluxation analysis: A proposed genealogy. Journal of Chiropractic Humanities. 2014;21(1):1-24.
2. Young KJ. Gimme that old time religion: The influence of the healthcare belief system of chiropractic's early leaders on the development of x-ray imaging in the profession. Chiropractic and Manual Therapies. 2014;22(1).
3. Young KJ, Bakkum BW, Siordia L. The Hangover: The Early and Lasting Effects of the Controversial Incorporation of X-Ray Technology into Chiropractic. Health and history. 2016;18(1):111-36.
4. Engel RM, Beirman R, Grace S. An indication of current views of Australian general practitioners towards chiropractic and osteopathy: a cross-sectional study. Chiropractic & Manual Therapies. 2016;24(1):37.
5. Young KJ. A Tale of Specialization in 2 Professions: Comparing the Development of Radiology in Chiropractic and Medicine. J Chiropract Humanit. 2019;26:3-18.
6. Adams J, Lauche R, Peng W, Steel A, Moore C, Amorin-Woods LG, et al. A workforce survey of Australian chiropractic: the profile and practice features of a nationally representative sample of 2,005 chiropractors. BMC complementary and alternative medicine. 2017;17(1):1-8.
7. Chiropractic Australia. Policy statement by Chiropractic Australia regarding the use of Diagnostic Radiology/Radiography in Chiropractic Practice 2015 [Available from: https://chiropracticaustralia.org.au/wp-content/uploads/2019/03/Diagnostic-Radiology-Policy.docx.pdf.
8. Chiropractic Australia. A Submission relating to Consultation Regulation Impact Statement on Diagnostic Imaging & Accreditation on Improving the quality and safety of Medicare funded diagnostic imaging services through the enhancement of regulatory and accreditation requirements. 2015.
9. Chiropractic Board of Australia. Chiropractic diagnostic imaging: Chiropractic Board of Australia; 2019 [Available from: https://www.chiropracticboard.gov.au/Codes-guidelines/FAQ/Conduct-performance/Chiropractic-diagnostic-imaging.aspx.
10. Jenkins HJ, Downie AS, Moore CS, French SD. Current evidence for spinal X-ray use in the chiropractic profession: A narrative review. Chiropractic and Manual Therapies. 2018;26(1).
11. Department of Health. Reducing unnecessary spinal x-rays 2017 [Available from: https://www1.health.gov.au/internet/main/publishing.nsf/Content/MBSR-reducing-unnecessary-spinal-x-rays.
12. Department of Health. Medicare Item Reports: 58108, 58115, 58120, 58121, 58126, 58127 (FY2015-16 FY 2020-YTD): Services Australia; 2021 [Available from: http://medicarestatistics.humanservices.gov.au/statistics/do.jsp?_PROGRAM=%2Fstatistics%2Fmbs_item_standard_report&DRILL=ag&group=58108%2C+58115%2C+58120%2C+58121%2C+58126%2C+58127&VAR=services&STAT=count&RPT_FMT=by+time+period+and+state&PTYPE=finyear&START_DT=201507&END_DT=202104
13. Johnson CD. X-ray Use in Chiropractic: Call for Papers. Journal of Chiropractic Humanities. 2019;26:1-2.
14. Jenkins HJ. Awareness of radiographic guidelines for low back pain: A survey of Australian chiropractors. Chiropractic and Manual Therapies. 2016;24(1).
15. Vom J, Williams I. Justification of radiographic examinations: What are the key issues? Journal of medical radiation sciences. 2017;64(3):212-9.

16. Brettle A. Implementing evidence-based practice: A guide for radiographers. Radiography (Lond). 2020;26 Suppl 2:S37-s41.
17. Medical Radiation Practice Board of Australia. Professional capabilities for medical radiation practitioners. 2020. p. 8-21.
18. Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC Medical Research Methodology. 2018;18(1):143.
19. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med. 2018;169(7):467-73.
20. Alcantara J, Ohm J, Kunz D. The chiropractic care of children. The Journal of Alternative and Complementary Medicine. 2010;16(6):621-6.
21. Anderson B. Critical Analysis of "X-Ray Imaging Is Essential for Contemporary Chiropractic and Manual Therapy Spinal Rehabilitation: Radiography Increases Benefits and Reduces Risks" by Oakley et al. Dose Response. 2018;16(4).
22. Askew JJ, Kranz KC, Whalen WM. Federal Employees' Compensation Act and Mandating the Use of X-ray for Chiropractic Management of Federal Employees: An Exploration of Concerns and a Call to Action. Journal of Chiropractic Humanities. 2020;27:11-20.
23. Bussieres A, Sales A, Ramsay T, Hilles S, Grimshaw J. Practice patterns in spine radiograph utilization among doctors of chiropractic enrolled in a provider network offering complementary care in the United States. Journal of Manipulative and Physiological Therapeutics. 2013;36(3):127-42.
24. Bussieres AE, Laurencelle L, Peterson C. Diagnostic Imaging Guidelines Implementation Study for Spinal Disorders: A Randomized Trial with Postal Follow-ups. J Chiropractic Educ. 2010;24(1):2-18.
25. Bussieres AE, Patey AM, Francis JJ, Sales AE, Grimshaw JM, Canada PPT, et al. Identifying factors likely to influence compliance with diagnostic imaging guideline recommendations for spine disorders among chiropractors in North America: a focus group study using the Theoretical Domains Framework. Implementation science : IS. 2012;7:82.
26. Bussieres AE, Sales AE, Ramsay T, Hilles SM, Grimshaw JM. Impact of imaging guidelines on X-ray use among American provider network chiropractors: Interrupted time series analysis. Spine Journal. 2014;14(8):1501-9.
27. Coleman R, Wolf K, Lopes M, Coleman J. History or science: The controversy over chiropractic spinography. Chiropractic History. 2013;33(1):66-81.
28. Corso M, Cancelliere C, Mior S, Kumar V, Smith A, Cote P. The clinical utility of routine spinal radiographs by chiropractors: A rapid review of the literature. Chiropractic and Manual Therapies. 2020;28(1).
29. De Carvalho D, Bussieres A, French SD, Wade D, Brake-Patten D, O'Keefe L, et al. Knowledge of and adherence to radiographic guidelines for low back pain: a survey of chiropractors in Newfoundland and Labrador, Canada. Chiropractic and Manual Therapies. 2021;29(1).
30. Kawchuk G, Goertz C, Axen I, Descarreaux M, French S, Haas M, et al. Letter to the Editor Re: Oakley PA, Cuttler JM, Harrison DE. X-Ray Imaging Is Essential for Contemporary Chiropractic and Manual Therapy Spinal Rehabilitation: Radiography Increases Benefits and Reduces Risks. Dose Response. 2018 Jun 19;16(2). Dose Response. 2018;16(4).
31. Klett R. Radiography before spinal manipulation. Reflections on a benefit-risk assessment. Manuelle Medizin. 2010;48(5):339-42.

32. Mizrahi DJ, Parker L, Zoga AM, Levin DC. National Trends in the Utilization of Skeletal Radiography From 2003 to 2015. J. 2018;15(10):1408-14.
33. Bussières A, Francis J, Patey A, Gagnon M, Sales A, Eccles M, et al. Identifying Factors Predictive of Managing Patients with Low Back Pain without Using X-Rays Among North American Chiropractors: Applying Psychological Theories to Evidence-Based Clinical Practice. BMJ quality & safety. 2013;22(Suppl 1):A26-A7.
34. Di Michele L, Thomson K, McEntee MF, Kenny B, Reed W. Knowledge translation: Radiographers compared to other healthcare professionals. Radiography. 2020;26:S27-S32.
35. Jenkins HJ, Downie AS, Moore CS, French SD. Current evidence for spinal X-ray use in the chiropractic profession: a narrative review. Chiropractic & manual therapies. 2018;26(1):48-.
36. Young K. Evaluation of Publicly Available Documents to Trace Chiropractic Technique Systems That Advocate Radiography for Subluxation Analysis: A Proposed Genealogy. Journal of chiropractic humanities. 2014;21(1):1-24.
37. Young K, Barclay WB, Lawrence S. The Hangover: The Early and Lasting Effects of the Controversial Incorporation of X-Ray Technology into Chiropractic. Health and History. 2016;18(1):111-36.
38. Department of Health. Diagnostic Imaging Accreditation Scheme Practice Accreditation Standards (from 1 January 2016) 2016 [2-10]. Available from: https://www1.health.gov.au/internet/main/publishing.nsf/Content/F4405D11CDDCBB5BCA257EF3001842F0/$File/DIAS%20Practice%20Accreditation%20Standards.pdf.

Appendix F – Decision letter from the editors of the Journal of Medical Radiation Sciences

From: cherry.agustin@newcastle.edu.au

To: Author 1

CC:

Subject: Journal of Medical Radiation Sciences - Decision on Manuscript ID JMRS-2021-098 [email ref: DL-SW-3-a]

Body: 18-Sep-2021

Dear Author 1:

We recognise that the impact of the COVID-19 pandemic may affect your ability to return your revised manuscript to us within the requested timeframe. If this is the case, please let us know.

Manuscript ID JMRS-2021-098 entitled "Factors Effecting Chiropractor-Referred Requests for Full-length Spinal Radiographic Examinations: A Scoping Review" which you submitted to Journal of Medical Radiation Sciences, has been reviewed. Some revisions to your manuscript have been recommended. Therefore, I invite you to respond to the comments appended below and revise your manuscript.

Before submitting your revisions:

1. Prepare a response to the reviewer comments appended below in point-by-point fashion. In order to expedite the processing of the revised manuscript, please be as specific as possible in your response and indicate the page numbers in the manuscript where you have addressed each comment.

2. Prepare a revised manuscript (word document), highlighting the changes you've made. Save this new document on your computer as you will be asked to upload it during the revision submission process. NOTE: Please be sure to keep in mind reviewer comments and incorporate your responses within the manuscript. There may well be areas where you disagree; for example, you may want to write, "A reviewer suggests that... However, I disagree because...". In any case, please try to address all of the concerns that are raised within the manuscript.

3. In addition to your revised manuscript with changes highlighted, please also save a "clean" copy where the changes are not marked.

To submit your revised manuscript:

1. Log in by clicking on the link below

*** PLEASE NOTE: This is a two-step process. After clicking on the link, you

will be directed to a webpage to confirm. ***

https://mc.manuscriptcentral.com/jmrs?URL_MASK=0df1ee474b6845068a95d2ffc1d53ca1

OR

Log into https://mc.manuscriptcentral.com/jmrs and click on Author Center. Under author resources, use the button "Click here to submit a revision". PLEASE DO NOT SUBMIT YOUR REVISIONS AS A NEW MANUSCRIPT.

2. Follow the on-screen instructions. First you will be asked to provide your "Response to Decision Letter"—this is the response to reviewer comments that you prepared earlier.

3. Click through the next few screens to verify that all previously provided information is correct.

4. File Upload: Delete any files that you will be replacing (this includes your old manuscript). Upload your new revised manuscript file with changes highlighted, a "clean" copy of your revised manuscript file, any replacement figures/tables, or any new files. Once this is complete, the list of files in the "My Files" section should ONLY contain the final versions of everything. REMEMBER: figures/tables should be in jpeg, tiff, or eps format. We hope that you will designate one of the figures in your paper to be considered for our online covers and potential publication on our blog.

5. Please supply an image for the graphical table of contents that will be used when your manuscript is accepted and published.

6. Review and submit: please be sure to double-check everything carefully so that your manuscript can be processed as quickly as possible.

Deadlines:
Because we are trying to facilitate timely publication of manuscripts submitted to Journal of Medical Radiation Sciences,your revised manuscript should be uploaded as soon as possible. If it is not possible for you to submit your revision in 8 weeks, we may have to consider your paper as a new submission. If you feel that you will be unable to submit your revision within the time allowed please contact me to discuss the possibility of extending the revision time.

Once again, thank you for submitting your manuscript to Journal of Medical Radiation Sciences and I look forward to receiving your revision.

Wiley Editing Services Available to All Authors
Should you be interested, Wiley Editing Services offers expert help with manuscript, language, and format editing, along with other article preparation services. You can learn more about this service option at www.wileyauthors.com/eeo/preparation. You can also check out Wiley's

collection of free article preparation resources for general guidance about writing and preparing your manuscript at www.wileyauthors.com/eeo/prepresources.

Sincerely,
Ms. Cherry Agustin
Editor in Chief, Journal of Medical Radiation Sciences
cherry.agustin@newcastle.edu.au

Editor in Chief Comments to Author:

Thank you for choosing JMRS.

Please include line numbers on the revised version. Please refer to these line numbers when replying to the reviewer comments.
Please use Word rather than pdf when submitting the main document file. Since I am unable to determine the word count with pdf, please check that your manuscript complies with the word limit.

Deputy Editor: 1
Comments to the Author:
Thank you for your interesting submission. The peer reviewers have provided feedback that needs to be responded to, please see below.

Associate Editor: 2
Comments to the Author:
Thank you for submitting this paper for consideration. Firstly as an undergraduate student, I commend you for having the initiative to submit work for publication.
As you will note there are some suggested modifications to this paper. Please address the points made by the reviewers and if you agree with them make the changes. If you don't agree with them please indicate why.
Author 3 has a long list of publications and although I imagine they were your academic supervisor they may well be in a position to help.
Finally, I look forward to seeing this paper again.

Appendix G – Feedback from Reviewer 1 (JMRS)

Comments to the Author: This is an important topic and I commend you work thus far. Some of the language feels a little judgmental and I am concerned that this may impact how the article is received. As you have stated, chiropractic and medical imaging professionals need to work together on this. I have made comments through the attached pdf of your work, which I hope you find useful.

Section	Page Number	Line Number	Reviewer Comment
Introduction	2	3	Do all chiropractors believe this? My understanding is that there are several schools of thought on this issue. I'm aware of 2 chiropractic associations with different views in Australia.
		6	Perception of whom?
		16	At first glance it seems that you have chosen not to reveal the proportion, but I see from the website referenced that the proportion has not been given. It may be worthwhile stating that fact.
		19	Are you using this term to bring together radiographers and radiologists? If so, this needs to be made clear, as later on in the paper there appears to be some confusion.
Methods	3	21	How closely did the papers need to be when 'alluding to' indications for imaging?
		27	How was the impact of a conflict of interest assessed?
Results	6	7	Suggest delete this word or give the figure
		19	Would be useful to compare the meaning of the term 'subluxation' across chiropractic and radiographic practitioners to explain the importance of this concept.
Discussion	11	10	Bit judgemental
		22	This comment appears to contradict your comment in the introduction regarding the 'core belief' of chiropractors
		22-28	This is a very long sentence, which makes it challenging to perceive the important aspects of what you are saying. I suggest splitting the sentence to make the meaning clearer.
		29	Judgemental language
	12	2	Suggest remove this word “still”
		4	A couple of examples of these 'red flags' would help the reader make a judgement.
		29	These are published findings from the Diagnostic Imaging committee. Stating this fact would strengthen your argument

Continued below…

Section	Page Number	Line Number	Reviewer Comment
Discussion (cont.)	13	4	Where has this data come from? That needs to be made clear
		28	'may' or 'must'?
	14	20	Decide which term to use: radiographers or diagnostic radiographers. In Australia the term is 'radiographer'. The term 'diagnostic radiographer' is commonly used in the UK
		27	See previous comment. Is this an overarching term for radiographers and radiologists?
		31	radiographers' - plural?
Conclusion	15	26	Suggest removing this word “pressing”

Appendix H – Feedback from Reviewer 2 (JMRS)

Comments to the Author: This was an interesting scoping review examining the use of full spine x-rays by chiropractors. This was a challenging review to synthesise given the broad topic area and variability in the articles found. I think that clearer definition of the specific aims of the review and a more structured approach to the results and discussion, with key findings for the specific aims outlined, would really help articulate the findings of this review more clearly. My detailed comments are summarised below.

Section	Reviewer Comments
Abstract	The aim outlined in the abstract is different to that in the body of the paper. See further comments regarding the aim below. The key findings in the abstract were not clearly articulated in the body of the paper – focusing on a few key findings consistently throughout the paper is suggested.
Introduction	The authors state 'Among the core beliefs of chiropractic...' I would argue that this is predominantly a historical belief and should be stated as such. Reference 13 is a call for papers on chiropractic radiology as does not seem to be related to the referenced text 'different authors advocating for both frequent or infrequent utilisation of spinal radiography in practice'
Aim	The aim is very general and difficult to interpret – what exactly is meant by 'issue of the referral for and utilisation of…'? It would be helpful if them aims could be clarified. Are you specifically trying to determine the utilisation of full spine radiographs, indications for referral, or the clinical utility etc. I understand it is a scoping review, but it would be helpful to frame the aims more specifically to help the reader understand the direction of the review.
Methods	Search strategy: Were variations of x-ray including radiographs, radiology also searched? Why were more chiropractic specific databases such as the Index to Chiropractic literature not searched as well? Were forward and backward citation searches of relevant articles performed? Eligibility criteria: It would be helpful if the eligibility criteria were more specific – in particular - were any specific study designs included? What is the definition of 'routine' practice? What do you mean by 'alluded' to specific indications? I think if the aims are clarified more specifically as suggested above then it would be easier to make the eligibility criteria clearer as well. While I understand why articles with potential conflict were excluded, I wonder whether for a scoping review it would still be better to present them with a clear disclaimer on the conflict, otherwise some themes may be missed, or less completely explored. There is no section on the selection of articles – was screening done by 2 authors? How were discrepancies resolved etc. Data charting and evidence synthesis: How was this process performed by the research team – were all authors involved, were conclusions and synthesis determined individually and then discussed or was it all determined by group consensus etc.

Continued below…

Section	Reviewer Comments
Results	In general, a more structured approach to the results would be good for clarity – perhaps start each theme with the number of papers addressing it and then breaking down sub-themes more clearly. I think more clarity in the aims as suggested above would The below paper doesn't appear to be included but may meet the inclusion criteria: Lew M, Snow GJ. Radiograph utilization and demographics in a chiropractic college teaching clinic. J Chiropr Med. 2012;11(4):242–8. The integration and clinical utility of spinal radiography in chiropractic practice: Although the quantification of xray use is limited it would be helpful to have some report of the results from different studies to give an idea of the variance. The heading of this theme includes clinical utility but there is little reporting of what clinical utility has been assessed. The regulation of spinal x-ray utilisation: I am not sure that this heading is addressing the paragraph – it doesn't seem to be just about regulation but also about appropriate/evidence-based use which isn't 'regulated' as such Alternatives to spinal radiography in chiropractic: This section could use a bit more description like the other sections as to what you mean by the heading. I feel that x-ray being a 'contraindication' is a bit of an overstatement and wonder if that is what those 3 papers said. Rather I would suggest that x-ray is not the most sensitive modality to detect serious pathology and that MRI would be preferred as stated in the last line of that section (although x-ray is still used if MRI etc. are unavailable). Risks associated with spinal radiography and the use of ionising radiation: Despite the heading and the content of the table the text only refers to the risk of ionising radiation. I feel mention in the text about other associated risks would be appropriate, especially given the more consistent responses related to these. The implementation of EBP by radiographers: I am not certain whether the search strategy used would have necessarily identified articles on radiographers screening referrals. I am also not sure if this is an issue specific to chiropractic, so articles about radiographers screening imaging referrals for appropriate indications in general may also fit well under this theme. In this section there are 4 references cited, but only 3 references in the table addressed this area – also the reference numbers appear inconsistent (33, 26 in the table, 34, 16 in the text etc.)
Discussion	I would suggest structuring the discussion to: key findings and comparison to other literature (of each theme), strengths and limitations, clinical or research implications. The first section of the discussion has a different heading to any of the themes – similar headings can help with the structure. The first 2 paragraphs of the discussion include a lot of chiropractic history/philosophy debates (e.g. straights vs mixers) and aren't really relevant to the results provided from the studies found in the review – for example you only mention terms such as subluxation in the introduction and discussion, but it is only briefly mentioned in the themes in the results. I would suggest keeping the discussion more targeted to the main findings of the review to give the reader clear take-home messages. Regulation of chiropractic referrals: the Medicare data is interesting, but it is not directly related to the results of the studies found in the review – some more discussion on these and less emphasis on the medicare findings is suggested. In particular, you haven't provided any references to back up that patients are now just paying out of pocket – this may be the case but perhaps be less definitive about it. It may also be worth looking at the amount of 2-region spine imaging over time, as this may have

Continued below…

Section	Reviewer Comments
Discussion (cont.)	increased to get around the inability to charge for 3-regions. Risks associated with spinal radiography: in the results you say that there is a split between studies and the risk of ionising radiation, but the discussion paragraph only discusses substantial risk which doesn't seem to reflect the studies found. I would also suggest further discussion of some of the other risks that are reported. Evidence practice and chiropractic referrals for radiography: radiographers needing to justify the imaging request is stated as an obligatory practice in the reference provided; however, it is not clear from the studies found whether this occurs for chiropractors or any other health care providers referring for imaging. Justification of the need of the imaging definitely rests with the chiropractor as outlined in the ARPANSA code of practice (https://www.arpansa.gov.au/sites/default/files/legacy/pubs/rps/rps19.pdf) which may need more focus in this discussion as well.
Conclusion	Given that the search was specific to chiropractic, I don't think that finding most of the authors to be chiropractors particularly surprising. If the focus of the review was to examine radiographers assessment of imaging justification a more specific search to this topic would have been needed to ensure all papers were found.
References	There appears to be duplication of references in the reference list (e.g. 10 and 35, 3 and 37) and some of the numbers in the text do not match the appropriate references – please check throughout.
Tables	The final table does not have a heading and I couldn't see a reference to it in the text

Appendix I – Author's reply to reviewers' comments

Author comments: Dear reviewers,

Thank you for taking the time to review our manuscript. Please find below our responses to the feedback raised in the review of our first submission. Comments have been organised according to page and line number within the revised manuscript for your convenience.

Responses to comments made by Reviewer One:

Section	Reviewer Comment			Author Response		
	Page	Line	Comment	Reply comment	Page	Line
Introduction	2	3	Do all chiropractors believe this? My understanding is that there are several schools of thought on this issue. I'm aware of 2 chiropractic associations with different views in Australia.	The language used has been reframed to stress the historical significance of chiropractic vertebral subluxation (CVS) in the context of chiropractic's position outside of mainstream medicine and has been reworded to include the fact that CVS is a point of contention within the chiropractic community.	2	2-9
		6	Perception of whom?	Reworded to "pushed chiropractic to the periphery" for clarity.	2	8
		16	At first glance it seems that you have chosen not to reveal the proportion, but I see from the website referenced that the proportion has not been given. It may be worthwhile stating that fact.	The issue of not being able to review the proportion of referrals made by chiropractors using publicly accessible data is discussed later in the article.	9	20-25
		19	Are you using this term [medical radiation practitioners] to bring together radiographers and radiologists? If so, this needs to be made clear, as later on in the paper there appears to be some confusion.	The language used throughout the article has been changed from "medical radiation practitioners" to "radiographers" when used in this context, unless otherwise specified	N/A	

Continued below…

Section	Reviewer Comment			Author Response		
	Page	Line	Comment	Reply comment	Page	Line
Methods	3	21	How closely did the papers need to be when 'alluding to' indications for imaging?	The wording of the eligibility criteria has been changed to be more specific to the aims of the review. The phrase in question has been deleted for clarity.	3	18-23
		27	How was the impact of a conflict of interest assessed?	The wording of the eligibility criteria has been changed to include "sources of funding…which may impact the validity of findings"	3	28-30
Results	6	7	Suggest delete this word or give the figure	Reworded for clarity.	6	14-16
		19	Would be useful to compare the meaning of the term 'subluxation' across chiropractic and radiographic practitioners to explain the importance of this concept.	A conventional definition of subluxation has now been provided to explain this critical difference between how the terminology is used in chiropractic as opposed to its medical usage.	5	22-24
Discussion	11	10	Bit judgemental	The phrase in question has been deleted.	N/A	
		22	This comment appears to contradict your comment in the introduction regarding the 'core belief' of chiropractors	The discussion has been reframed to avoid too much emphasis on the historical and philosophical arguments of chiropractic, as per Reviewer 2's comments. As such the comment in question has been deleted.	N/A	
		22-28	This is a very long sentence, which makes it challenging to perceive the important aspects of what you are saying. I suggest splitting the sentence to make the meaning clearer.	The sentence has been rephrased for clarity and has been moved to the results section.	8	17-21
		29	Judgemental language	The phrase in question has been deleted.	N/A	
	12	2	Suggest remove this word "still"	The phrase in question has been deleted.	N/A	
		4	A couple of examples of these 'red flags' would help the reader make a judgement.	Examples have been provided as part of the results section.	6	30
		29	These are published findings from the Diagnostic Imaging committee. Stating this fact would strengthen your argument	References to these findings have been rephrased to include their providence i.e. the Committee for Medical Imaging in LBP.	11	32

Continued below…

Section	Reviewer Comment			Author Response		
	Page	Line	Comment	Reply comment	Page	Line
	13	4	Where has this data come from? That needs to be made clear	Reference added: (8) Medicare Benefits Schedule Review Taskforce. First Report from the Diagnostic Imaging Clinical Committee - Low Back Pain. In: Health Do, editor. Canberra: Department of Health; 2016. p. 47-9.	11	29-32
		28	'may' or 'must'?	The phrase in question has been deleted.	N/A	
	14	20	Decide which term to use: radiographers or diagnostic radiographers. In Australia the term is 'radiographer'. The term 'diagnostic radiographer' is commonly used in the UK	The language used throughout the article has been changed from “medical radiation practitioners” to “radiographers” when used in this context, unless otherwise specified		
		27	See previous comment. Is this an overarching term for radiographers and radiologists?	As above	N/A	
		31	radiographers' - plural?	Rephrased for clarity.	11	11-12
Conclusion	15	26	Suggest removing this word “pressing”	The word has been removed.	12	26

Responses to comments made by Reviewer Two:

Section	Reviewer Comments	Author Response		
		Reply comment	Page	Line
Abstract	The aim outlined in the abstract is different to that in the body of the paper. See further comments regarding the aim below.	The abstract has been revised to more accurately reflect the purpose of the study.	1	4-6
	The key findings in the abstract were not clearly articulated in the body of the paper – focusing on a few key findings consistently throughout the paper is suggested.	The results as detailed in the abstract are now consistent throughout the paper.	1	12-18
Introduction	The authors state 'Among the core beliefs of chiropractic...' I would argue that this is predominantly a historical belief and should be stated as such.	As per comments made in response to Reviewer 1, the language used has been reframed to stress the historical significance of chiropractic vertebral subluxation (CVS). Otherwise, it would go beyond the scope of the review to examine the prevalence of beliefs of different factions of chiropractors in subluxation theory.	2	2-9
	Reference 13 is a call for papers on chiropractic radiology as does not seem to be related to the referenced text 'different authors advocating for both frequent or infrequent utilisation of spinal radiography in practice'	The phrase in question has been deleted.	N/A	
	The aim is very general and difficult to interpret – what exactly is meant by 'issue of the referral for and utilisation of…'? It would be helpful if them aims could be clarified. Are you specifically trying to determine the utilisation of full spine radiographs, indications for referral, or the clinical utility etc. I understand it is a scoping review, but it would be helpful to frame the aims more specifically to help the reader understand the direction of the review.	The aim has been reworded for clarity.	2	28-30
Methods	Search strategy: Were variations of x-ray including radiographs, radiology also searched?	Variations of x-ray including radiographs and radiography were searched. The searched strategy has been updated to reflect this.	3	8-9

Continued below…

Section	Reviewer Comments	Author Response		
		Reply comment	Page	Line
Methods (cont.)	Why were more chiropractic specific databases such as the Index to Chiropractic literature not searched as well?	As noted in the search strategy, we included AMED in our search for literature, a database which indexes articles primarily from alternative and complimentary medicine journals. Notably it draws on the same chiropractic journals as the Index of Chiropractic Literature (ICL). We were more easily and seamlessly able to export data from AMED via Ovid to EndNote X9 for analysis than the ICL and were able to perform a more effective search in the Ovid search platform than the ICL webpage. A full list of the journals which AMED indexes can be found here: https://wkhealth.force.com/ovidsupport/s/article/Where-can-I-find-a-list-of-journals-indexed-in-the-AMED-Allied-and-Complementary-Medicine-database-1489081397374	3	9
	Were forward and backward citation searches of relevant articles performed?	Since receiving this feedback, forward and backward citation searches of eligible articles were performed to improve the rigour of the search strategy. Additional articles were identified as a result of implementing these additional searches (see Figure 1)	3	12-13
	Eligibility criteria: It would be helpful if the eligibility criteria were more specific – in particular – were any specific study designs included?	The eligibility criteria has been revised to incorporate more specific language.	3	23-31
	What is the definition of 'routine' practice?	A definition of 'routine' in the context of repeat FLS radiography has been provided in the results section.	6	20-22
	What do you mean by 'alluded' to specific indications?	The wording of the eligibility criteria has been changed to be more specific to the aims of the review. The phrase in question has been deleted for clarity.	3	18-23

Continued below…

Section	Reviewer Comments	Author Response		
		Reply comment	Page	Line
Methods (cont.)	I think if the aims are clarified more specifically as suggested above then it would be easier to make the eligibility criteria clearer as well.	The aim has been reworded for clarity.	2	28-30
	While I understand why articles with potential conflict were excluded, I wonder whether for a scoping review it would still be better to present them with a clear disclaimer on the conflict, otherwise some themes may be missed, or less completely explored.	We have since been able to identify two eligible articles (4, 3) by the same authors whose articles we chose to exclude, in which no conflicts of interest or funding sources were declared. These articles are representative of the greater body of work of the authors in question and have been examined and contrasted against other eligible articles (see Tables 1 and 2)	N/A	
	There is no section on the selection of articles – was screening done by 2 authors? How were discrepancies resolved etc.	The methods used to chart data has been revised to include the contribution of individual authors.	4	3-5
	Data charting and evidence synthesis: How was this process performed by the research team – were all authors involved, were conclusions and synthesis determined individually and then discussed or was it all determined by group consensus etc.	As above	4	3-5
Results	In general, a more structured approach to the results would be good for clarity – perhaps start each theme with the number of papers addressing it and then breaking down sub-themes more clearly.	The results section has been reorganised to match this proposed structure.	4-9	N/A
	I think more clarity in the aims as suggested above would also help you in framing this section more clearly as well	The aim has been reworded for clarity.	2	28-30
	The below paper doesn't appear to be included but may meet the inclusion criteria: Lew M, Snow GJ. Radiograph utilization and demographics in a chiropractic college teaching clinic. J Chiropr Med. 2012;11(4):242–8.	We also found this article during our literature review, however found it difficult to extract relevant data about full-length spinal radiography from the article. The authors chose to split FLS X-ray encounters into 3 individual encounters for cervical, thoracic and lumbar spine, and did not examine the use of FLS X-rays alone. The article was excluded as per the eligibility criteria.	N/A	

Continued below…

Section	Reviewer Comments	Author Response		
		Reply comment	Page	Line
Results (cont.)	The integration and clinical utility of spinal radiography in chiropractic practice: Although the quantification of xray use is limited it would be helpful to have some report of the results from different studies to give an idea of the variance.	This paragraph has been deleted.	N/A	
	The heading of this theme includes clinical utility but there is little reporting of what clinical utility has been assessed.	This heading for this theme has been revised to 'Clinical indications for FLS radiography' to more accurately reflect the findings explored herein.	6-7	N/A
	Alternatives to spinal radiography in chiropractic: This section could use a bit more description like the other sections as to what you mean by the heading.	In light of feedback provided from Reviewers 1 and 2, the data was recharted and this theme was removed. Alternatives to spinal radiography are discussed in 'Clinical indications for FLS radiography'	7	1-3
	I feel that x-ray being a 'contraindication' is a bit of an overstatement and wonder if that is what those 3 papers said.	The phrase in question has been deleted.	N/A	
	Rather I would suggest that x-ray is not the most sensitive modality to detect serious pathology and that MRI would be preferred as stated in the last line of that section (although x-ray is still used if MRI etc. are unavailable).	The preferability and accessibility of MRI and CT spinal imaging are discussed in 'Clinical indications for FLS radiography'	7	1-5
	The implementation of EBP by radiographers: I am not certain whether the search strategy used would have necessarily identified articles on radiographers screening referrals. I am also not sure if this is an issue specific to chiropractic, so articles about radiographers screening imaging referrals for appropriate indications in general may also fit well under this theme.	In light of feedback provided from Reviewers 1 and 2, the data was recharted and this theme was removed. The impacts of this issue on radiographers was explored in the discussion.	10	32
	In this section there are 4 references cited, but only 3 references in the table addressed this area – also the reference numbers appear inconsistent (33, 26 in the table, 34, 16 in the text etc.)	Referencing throughout the article has been reviewed and amended for clarity. The section in question has been deleted from the manuscript.	N/A	

Continued below…

Section	Reviewer Comments	Author Response		
		Reply comment	Page	Line
Discussion	I would suggest structuring the discussion to: key findings and comparison to other literature (of each theme), strengths and limitations, clinical or research implications.	The discussion has been restructured in light of this feedback and now follows this proposed structure.	9-12	N/A
	The first 2 paragraphs of the discussion include a lot of chiropractic history/philosophy debates (e.g. straights vs mixers) and aren't really relevant to the results provided from the studies found in the review – for example you only mention terms such as subluxation in the introduction and discussion, but it is only briefly mentioned in the themes in the results. I would suggest keeping the discussion more targeted to the main findings of the review to give the reader clear take-home messages.	The discussion has been reworked to place less emphasis on the historical significance and philosophical arguments of CVS, however this has been touched on in the results section (see Theme 1). We felt it was important to keep some discussion of these paradigms in the article as a significant amount of the eligible literature included in the review examined the historical impacts of CVS theory on the use of FLS radiography in contemporary chiropractic.	5	16-33
	The Medicare data is interesting, but it is not directly related to the results of the studies found in the review – some more discussion on these and less emphasis on the medicare findings is suggested.	We have now structured the discussion surrounding the MBS data to provide contextual evidence for the previously reported overutilisation of FLS X-rays by chiropractors and current trends in utilisation.	11	17-23
	In particular, you haven't provided any references to back up that patients are now just paying out of pocket – this may be the case but perhaps be less definitive about it.	Reference added: (8) Medicare Benefits Schedule Review Taskforce. First Report from the Diagnostic Imaging Clinical Committee - Low Back Pain. In: Health Do, editor. Canberra: Department of Health; 2016. p. 47-9.	11	29-32
	It may also be worth looking at the amount of 2-region spine imaging over time, as this may have increased to get around the inability to charge for 3-regions.	We have included two region spinal X-ray MBS data over the same period and have made reference to its potential use as a loophole for chiropractic imaging as opined by the diagnostic imaging committee (see Figure 2).	11	27-33
	Risks associated with spinal radiography: in the results you say that there is a split between studies and the risk of ionising radiation, but the discussion paragraph only discusses substantial risk which doesn't seem to reflect the studies found.	The paragraph in question has been deleted. The focus of the discussion visa vee risks of FLS radiography has been reframed to incorporate discussion of reported risks of overdiagnosis, underdiagnosis and economic waste.	12	10-30

Continued below…

Section	Reviewer Comments	Author Response		
		Reply comment	Page	Line
Discussion (cont.)	I would also suggest further discussion of some of the other risks that are reported.	As above	12	10-30
	Evidence practice and chiropractic referrals for radiography: radiographers needing to justify the imaging request is stated as an obligatory practice in the reference provided; however, it is not clear from the studies found whether this occurs for chiropractors or any other health care providers referring for imaging. Justification of the need of the imaging definitely rests with the chiropractor as outlined in the ARPANSA code of practice (https://www.arpansa.gov.au/sites/default/files/legacy/pubs/rps/rps19.pdf) which may need more focus in this discussion as well.	We have reframed the discussion to emphasise the importance of a collaborative approach in addressing this issue moving forward..	10	2-7
Conclusion	Given that the search was specific to chiropractic, I don't think that finding most of the authors to be chiropractors particularly surprising.	The phrase in question has been deleted. Reference has been made to the fact that the review found no previous articles addressing FLS radiography use by chiropractors which also examined the impacts of the issue on radiographers.	5	1-3
	If the focus of the review was to examine radiographers assessment of imaging justification a more specific search to this topic would have been needed to ensure all papers were found.	The conclusion has been reworded to place less emphasis on radiographer assessment of justification, but rather the importance of beginning dialogues with chiropractic referrers as a way of addressing this issue moving forward.	12-13	N/A
References	There appears to be duplication of references in the reference list (e.g. 10 and 35, 3 and 37) and some of the numbers in the text do not match the appropriate references – please check throughout.	Referencing throughout the article has been reviewed and amended for clarity.	N/A	
Tables	The final table does not have a heading and I couldn't see a reference to it in the text	A heading has been added to Table 2.	N/A	

Appendix J – Link to online supplementary evidence library

Additional supporting evidence for this study can be found via the following Google Drive link:

https://drive.google.com/drive/folders/1ePqh7ppn8H92bQC3zStIH0LKzmLFdIUK?usp=sharing

Index of online supplementary evidence library

File Number	File name/contents
1	**DR_16data.enlp** EndNote library containing all non-duplicate articles found in the initial data search, organised according to database of providence and eligibility screening.
2	**DR_16ref.enlp** EndNote library containing all articles cited in the manuscript with full-text PDF's or index URL's attached.
3	**Data Chart DR_16.xlsx** Excel spreadsheet showing data charting process, research notes explaining how the article met the eligibility criteria as well as article providence if found during forward and backward citation searches.
4	**MBS_Data_1935617707.xlsx** Relevant MBS reimbursement data for three and four region spinal radiography between FY2010-11 and FY2020-21. (Ref. 33 in the manuscript)
5	**MBS_Data_1950776285.xls** Relevant MBS reimbursement data for two region spinal radiography between FY2010-11 and FY2020-21. (Ref. 34 in the manuscript)