

**Identifying Factors Likely to Influence the Use of Diagnostic
Imaging Guidelines for Adult Spine Disorders Among
North American Chiropractors**

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“The power to question is the basis of all human progress.”

Indira Gandhi

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LIST OF ABBREVIATIONS AND ACRONYMS USED IN THIS THESIS

ASH	American Specialty Health Network	ITS	Interrupted time series
		KT	Knowledge Translation
CI	Confidence interval	LBP	Low back pain
CIHR	Canadian Institutes of Health Research	MRI	Magnetic resonance imaging
		NP	Neck pain
CPG	Clinical practice guideline	OLT	Operant Learning Theory
CT	Computerized tomography	PEM	Printed Educational Material
DIGASD	Diagnostic Imaging Guidelines for Adult Spine Disorders	PN	Provider Network
		Red Flags	Indicators of serious pathology
EBM	Evidence-based medicine	RCT	Randomized control trial
e.g.	for example	SD	Standard deviation
EMR	Electronic medical record	SRHI	Self-Reported Habit Index
EPOC	Cochrane Effective Practice and Organizational Change (Review Group)	TDF	Theoretical Domains Framework
		TIB	Theory of Interpersonal Behaviour
et al.	and others	TPB	Theory of Planned Behaviour
GP	General practitioner	UK	United Kingdom
HMO	Health Manage Organization	US	United States
i.e.	that is	Vs	Versus

THESIS ABSTRACT

The high prevalence of back and neck pain results in enormous social, psychological, and economic burden. Most seeking help for back or neck pain consult general practitioners or chiropractors. Chiropractic is a regulated health profession (serving approximately 10 – 15% of the population) that has contributed to the health and well-being of North Americans for over a century. Despite available evidence for optimal management of back and neck pain, poor adherences to guidelines and wide variations in services have been noted. For instance, overuse and misuse of imaging services have been reported in the chiropractic literature. Inappropriate use of spine imaging has a number of potential adverse outcomes, including inefficient and potentially inappropriate invasive diagnosis and subsequent treatment, and unnecessary patient exposure to ionizing radiation.

Although evidence-based diagnostic imaging guidelines for spinal disorders are available, chiropractors are divided on whether these guidelines apply to them. While guidelines can encourage practitioners to conform to best practices and lead to improvements in care, reviews have demonstrated that dissemination of guidelines alone is rarely sufficient to optimise care. Evidence regarding effective methods to promote the uptake of guidelines is still lacking. There is growing acceptance that problem analysis and development of interventions to change practice should be guided by relevant theories and tailored to the target audience. To date, very little knowledge translation research has addressed research-practice gaps in chiropractic. This thesis reports rigorous methods to: (1) assess practice and providers' characteristics, (2) determine baseline rates and variations in spine x-ray ordering, (3) evaluate the impact of disseminating guidelines to optimise spine x-ray ordering, and (4)

assess determinants of spine x-ray ordering and potential targets for change prior to the design of a tailored intervention.

A mixed method using two disciplinary perspectives (epidemiology and psychology) was undertaken. A cross-sectional analysis of administrative claims data was carried out on a sample of chiropractors enlisted in a large American provider network. Despite available clinical practice guidelines, wide geographical variations in x-ray use persist. Higher x-ray ordering rates were associated with practice location (Midwest and South US census regions), setting (urban, suburban), chiropractic school attended, male provider, employment, and years in practice. The impact of web-based guideline dissemination was evaluated over a five year period using interrupted time series and demonstrated a stepwise relative reduction of 5.3% in the use of x-rays. Passive guidelines dissemination appeared to be a simple, cost effective strategy in this setting to improve but not optimise x-ray ordering rates. Focus groups using the theoretical domains framework were conducted among Canadian and US chiropractors to explore their beliefs about managing back pain without x-rays. Findings were used to develop a theory-based survey to identify theoretical constructs predicting spine x-ray ordering practice. Psychological theories and theoretical constructs explained a significant portion of the variance in both behavioural simulation and intention.

Results from this thesis provide an empirically-supported, theoretical basis to design quality improvement strategies to increase guidelines adherence and promote behaviour change in chiropractic. Other researchers interested in improving uptake of evidenced-based information could use this method in their own setting to investigate determinants of behaviour among other professional groups. Future research may use knowledge gained to

inform the development and evaluation of a theory-based tailored intervention to improve guideline adherence and reduce the use of spine x-rays among targeted providers.

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Soon after publishing three clinical practice guidelines in chiropractic (a five year project), I realized hardly anyone would read these, either because they were too complex or practitioners are simply too busy caring for patients. This observation has motivated me to undertake this thesis in knowledge translation and find out who were the leading scientists in this field.

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are university graduates and have brilliant careers as well. I am grateful for their support and understanding.

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CHAPTER ONE

INTRODUCTION AND OVERVIEW

Developing a scientific rationale to inform the design of a KT intervention to address overuse of spine x-rays in chiropractic.

So many things I have learned from you...

I have learned that everybody wants to live at the top of the mountain, forgetting that how we climb is all that matters.

Gabriel Garcia Marquez - Latin American writer

This thesis in Population Health represents the culmination of a comprehensive doctoral program of education and research. This work strives to better understand factors likely to influence the use of diagnostic imaging guidelines for spine disorders among North American chiropractors. The overall goal is to establish a scientific rationale for interventions to translate research findings (appropriate imaging for spine disorders) into chiropractic practice.

We applied qualitative and quantitative methods in sequential order to explore structural and behavioural determinants of professional behaviour. This thesis is comprised of four individual studies, each of which resulted in a paper for publication. Chapters two through five report the methods and results of four studies documenting: (1) baseline rates and variations in x-ray ordering practice among a group of American provider network (PN) chiropractors, (2) the impact of web-based dissemination of guideline recommendations within this PN, (3) barriers and facilitators to managing back pain patients without x-rays in two different settings, and (4) predictors of behavioural intention and simulation to manage low back pain patients without imaging among Ontario chiropractors.

In this chapter, I begin with an overview of a clinical problem I felt needed to be addressed in chiropractic. The overuse and misuse of spine x-rays for uncomplicated back and neck pain represent a significant population health concern. Despite the available evidence for managing these conditions, chiropractors remain divided on whether current recommendations on spine x-rays apply to them. I introduce my thesis research as a mean to address this problem.

Clinical Context: A population health issue

Musculoskeletal disorders

One important reason patients consult primary care professionals (including general practitioners and chiropractors) is for musculoskeletal conditions [1]. Musculoskeletal conditions (spinal pain, consequences of injuries, osteoporosis, and arthritis) result in enormous social, psychological, and economic burden to society [1-8], and are the leading cause of physical disability in the US [9]. A Health Canada study revealed musculoskeletal disorders ranked second after cardiovascular disease in terms of highest cost of burden of illness in Canadian society, at over \$16.4 billion (direct and indirect costs of \$2.6 billion and \$13.7 billion respectively) or 10.2% of the total cost of illness in 1998 [10]. That same year, morbidity costs due to long-term disability from musculoskeletal disorders totalled \$12.6 billion, 37.5% (\$4.7 billion) of which was due to spine disorders alone. This figure is significantly higher than long-term disability costs related to all other diagnostic categories, including afflictions of the nervous system (\$4.1 billion), cardiovascular disease (\$3.2 billion) and mental disorders (\$2.2 billion) [10].

Spine disorders

Neck and back pain can be disabling conditions, with a course characterized by periods of remission and exacerbation. The point prevalence of neck pain (NP) and low back pain (LBP) in the general adult population is estimated at 15% and 25% respectively [3, 11, 12]. Life-time prevalence ranges between 30% and 70% for NP, and is approximately 80% for LBP [3, 13-15]. In the US, total costs associated with NP and LBP is estimated at over US \$100 billion annually and is rapidly increasing [3, 5, 16, 17]. While a major portion are indirect costs (disability payments, loss of productivity, etc.),

direct costs (investigation and treatment) are also very high, with diagnostic imaging of the lumbar spine representing a large segment of this [18-22].

The vast majority of patients have uncomplicated neck and back pain [23]. In this thesis, 'uncomplicated', also called 'non-specific' neck and back pain, refers to adult patients (age 18-65) with neck or back symptoms of short or long duration, but with no recent trauma, no progressive neurological deficits, and no alerting features (red flags) of serious conditions such as tumors, infections or fractures.

The chiropractic profession

Most patients seeking help for back or neck pain consult family physicians or chiropractors [24-27]. Chiropractic is a regulated health profession (serving approximately 10 – 15% of the population) that has contributed to the health and well-being of North Americans for over a century. The chiropractic profession may be defined by the following characteristics [28]: a defined scope of practice with established standards of practice; a control entry to the profession; inclusion in the limited group of regulated health professionals who deliver primary contact health care; and an established and growing base of substantive evidence for the evaluation and treatment of neuromusculoskeletal conditions. Despite available evidence for optimal management of back and neck pain [29-31] however, poor adherence to guidelines and wide variations in services have been noted [30, 32, 33]. Efforts to embrace and enhance evidence-based practice have been hampered by: 1) the limited research capacity in chiropractic, with less than 1% of the chiropractic profession conducting research in Canada [34]; 2) the low value placed on scientific knowledge and research by some clinicians; 3) the large percentage of the chiropractors in solo practice, which limits opportunities to interact with colleagues and other professions [35, 36]; 4) the limited

exposure to using decision support systems (clinical decision rules, guidelines, etc); 5) the lack of co-ordination of efforts between researchers, practitioners and stakeholders to successfully disseminate and implement guidelines; and 6) ongoing debates about the chiropractic profession's own identity [37] and related contrasting approaches (experiential vs. evidence-based) [38-40] resulting in low coherence of beliefs and attitudes. Gaining a better understanding of chiropractors' clinical experiences and beliefs and of the dissonance with research evidence may help translate research into practice to improve patient care [41].

Overuse and misuse of x-rays

One area where there is a need to reduce the gap between evidence and practice is the field of diagnostic imaging. Evidence of inappropriate use of imaging services have been reported in the chiropractic literature [42-47].

Internationally

Surveys conducted between 1985 and 1995 among European and North American chiropractors indicated that between 54-93% of patients underwent spinal x-rays as part of the initial assessment [46, 48]. However, the use of spine x-rays has declined over the recent years [49]. X-ray utilization rates for new chiropractic patients was 30% in Switzerland in 1998, and less than 25% in the UK and in the US in 2000 [50-53]. Few studies have attempted to describe practice patterns in x-ray use among chiropractors in the United-States, and data collected prior to 1995 [54-58] may no longer reflect current practice. Even fewer studies assessed established chiropractic provider networks [59-61], and these used convenience samples and therefore may not be representative of the population. Provider networks (PN) refer to a private organization that provides

health care for health plans in the US with coverage for specific services by enlisted care providers [62].

Nationally

A recent survey in Canada suggests that the percentage of chiropractic patients who are x-rayed at least once per episode has gradually declined from 48% in 1997 to 35% in 2011 [36]. The survey suggested wide variations in x-ray use across provinces, with Quebec showing no evidence of a downward trend over time. In contrast, the proportion of claims for any x-ray claims submitted by chiropractors to the Ontario Health Insurance Plan (OHIP) decreased from 18.3% to 14.2% between 1994 and 2001, despite a growth in the number of claimants, chiropractors, and population [63]. As chiropractic services were delisted from OHIP in December 2004, objective data on x-ray utilization were no longer available at the time we undertook this project. While chiropractors initially perceived OHIP delisting had a detrimental effect on patient volumes and practice revenues [64], little is known about its impact on managing uncomplicated back pain without x-rays or chiropractors' intention to order spine x-rays for such condition.

Routine use of spine imaging and clinical outcomes

Despite a minority of patients having serious spine conditions, there have been dramatic increases in the use and costs of certain services in the primary care setting with little evidence of improved patient outcomes [32, 65-68]. For instance, lumbar spine radiography rarely reveals the source of the patient complaint, and does not improve clinical outcomes (short and long term quality of life, pain and function, mental health or overall improvement) compared to usual clinical care without immediate imaging [69]. The yield of a positive finding on imaging studies that would alter management is

considered extremely low (only 1 in 2500 lumbar spine radiographs) in the absence of red flags [70].

While it is likely that most chiropractors obtain spine x-rays for clinical reasons, such as confirming a diagnosis of pathology as recommended by evidenced-based guidelines, many continue to use radiography routinely even if reasons mentioned for doing so are not supported by the literature [42, 71, 72]. Survey data from Ontario, Canada [42] suggest conflicting views about the benefits and harms of spine x-rays that likely influence x-ray utilisation patterns, including: 1) to screen for and prevent rare possible complications associated with spinal manipulative therapy; 2) nonclinical motives, including patient preference and satisfaction; medico-legal concerns; political influence and administrative factors; 3) for postural and biomechanical analysis of spinal disorders both before and during the provision of manual therapy; 4) to provide patients with a more accurate prognosis; 5) because the effects of ionizing radiation exposure on human health is considered to be negligible.

Evidence of harm from spine imaging

Risks of routine imaging include unnecessary patient radiation exposure [73-75]. Cervical spine radiographs are equivalent to reported doses received for routine chest films, whereas the effective radiation doses of lumbar spine x-rays are approximately 40 times the dose for routine chest films [76]. Patients who undergo routine lumbar x-rays are more likely to report poor outcome and seek follow-up care [22]. These patients are also more likely to receive unnecessary follow-up advanced imaging for incidental findings, including Magnetic Resonance Imaging and Computed Tomography [77]. In

turn, advance spine imaging is associated with increase rates of lumbar surgery and significant costs [77-79].

Evidence-based recommendations for imaging of uncomplicated spine conditions

Considering the poor association between x-ray findings and NP or LBP, the high radiation dose to patients and the poor cost/benefit ratio [80], current evidence suggest that spine x-rays are unnecessary during initial evaluation of patients younger than age 65 with low-back or neck pain unless features suggestive of serious underlying conditions (red flags) are present [31, 69, 81, 82]. Estimated accuracy of the history in the diagnosis of spinal diseases that cause NP and LBP has been reviewed elsewhere [82, 83]. For instance, the combination of four clinical features to screen for cancer in low-back pain patients (age over 50 years, previous history of cancer, unexplained weight loss, and failure to improve after one month of conservative therapy), has a sensitivity of 100%, a specificity of 60%, and a positive and negative likelihood ratio of 2.5 and 0 respectively [82, 83]. Absence of clinical indicators of serious pathology (i.e., red flags) should help reassure clinicians that proceeding with conservative care without spine imaging is appropriate.

What is the appropriate rate of spine x-rays?

Precise estimates for the appropriate rate of spine x-rays in the primary-care setting have not been formally determined. For the vast majority of back pain sufferers (over 85% of patients) the cause remains unknown [84] and spine x-ray is not informative [69]. Among conditions likely to alter clinical management and require specialized medical attention, serious underlying diseases (cancer, infection, inflammatory arthritis) and neurologic impairments (disc herniation, spinal stenosis, cauda equine syndrome)

represent 5% of causes of back pain [83]. Other specific causes likely to prompt investigation include osteoporotic compression fracture (4%), spondylolisthesis (2%), structural deformities of the spine (<1%), and visceral disease (2%). For a number of these conditions, other modalities are a preferred option [83]. For instance, MRI (or CT) is recommended for back and leg pain unresponsive to conservative care, severe neurologic compromise, major trauma, and strong clinical suspicion of vertebral infection or cancer [85]. Further, spine x-rays identify many abnormalities that are unrelated to back symptoms such as degenerative processes of disc and facets because such abnormalities are equally prevalent in persons with and without back pain.

Uptake of research evidence and clinical practice guidelines

The uptake of research evidence into practice to improve health outcomes is a long and complex process. Numerous strategies have been used to ease this process. Traditional ways of keep up to date include reading peer-reviewed journals and attending educational meetings. However, the abundance of literature produced (with an average of 75 trials and 11 systematic reviews published daily) is overwhelming, and their content does not always meet the need of clinicians [86]. Further, this model assumes that care providers have the time and necessary skills to appraise clinical research and are both motivated and able to introduce new evidence into practice [87]. While attending educational meetings tends to be generally effective for both appropriate care and appropriate use outcomes, their overall effect tends to be small [88]. Clinical practice guidelines (CPGs) are one important way to help implement research findings. These tools have the potential to improve the quality and safety of healthcare [89, 90].

Clinical practice guidelines (CPGs) are particularly useful where overuse and misuse of services exist, as they aim to describe appropriate care based on the best available scientific evidence and broad consensus while promoting efficient use of resources [91, 92]. The Institute of Medicine recently revised the definition of CPGs as: *'Statements that include recommendations intended to optimize patient care that are informed by a systematic review of evidence and an assessment of the benefits and harms of alternative care options'* [93]. Given the high prevalence and significant costs associated with back and neck pain, several evidence-based CPG's and best evidence synthesis are available for optimal management [29-31]. While appropriately developed CPGs are a necessary first step [93-95], much remains to be known on how best to effectively implement CPGs.

Poor adherence to CPGs has been noted across spine care providers [27, 30, 32, 33, 96, 97]. Guideline dissemination and implementation strategies can encourage practitioners to conform to best practices and lead to improvements in care [89, 90, 98-103]. However, high quality studies documenting effectiveness and efficiency of CPG's dissemination and implementation strategies are scarce [102]. Further, evidence to support guideline implementation strategies among allied health professionals is lacking [104]. In this last review, only three of the fourteen included studies focused on physiotherapists and there were none on chiropractors [104].

Despite available evidence, little is known about which CPG dissemination and implementation interventions are most effective under what circumstances [102]. On their own, commonly used strategies such as printed educational materials including clinical guidelines (PEMs), audit and feedback, educational outreach, and educational meetings appear to have a small-to-modest impact on practice (median effect sizes of 4 to 6%), while there are slightly larger effects local opinion leaders [88, 105]. Reminders as well as patient-mediated and tailored interventions have mixed effects for appropriate care, and very few studies have compared multifaceted interventions to single interventions [88].

A recent review of interventions designed to improve the use of imaging for musculoskeletal symptoms [106] could not draw any firm conclusions about the most effective interventions to reduce x-ray ordering behaviour for the management of low back pain. For instance, distribution of printed educational materials (PEM), the most common intervention evaluated, showed mixed effects among primary care practitioners.

In contrast, other reviews suggest PEM are generally effective strategies for improving process of care among physicians resulting in small to modest improvements [102, 107]. Because few of the included studies provided any rationale for their choice of intervention and used only limited contextual data, there may be important differences in the context and barriers between studies that assessed presumably similar interventions [108]. The effectiveness of an intervention appears to vary across characteristics of the evidence itself (i.e. guidelines, best practice...), the context and setting where new evidence will be implemented, interactions with other ongoing initiatives, and interactions across determinants [109-115]. Furthermore, identifying determinants of behaviour change likely to influence the implementation of practice guidelines is a recommended initial step to tailor interventions to improve patient care [115-118]. Determinants of behaviour change refer to barriers (factors likely to limit or restrict implementation of evidence in clinical practice) and facilitators (factors more susceptible to promote or help implement evidence in clinical practice) [119]. A review of the effect of tailored interventions on professional practice and health care outcomes suggested that much remains to be done to translate identified barriers into tailor-made implementation interventions [116]. Included studies were unable to clarify whether identified barriers were valid, which ones were the most important, whether all barriers were identified and if they had been addressed by the intervention chosen [116]. Furthermore, few studies used a mixed-method design or existing theories, models or framework to strengthen the design of barrier assessment [120].

Research-practice gaps and knowledge translation: Present state of knowledge

I have underlined some of the challenges associated with implementing clinical practice guidelines to promote the uptake of research evidence in the area of spine care within chiropractic. However, it is important to mention that inappropriateness of care and challenges to reduce the research-practice gap is not restricted to certain health conditions, health professions, context (primary vs. specialized care) or settings (developed vs. underdeveloped countries) [105]. A landmark report, 'Bridging the quality chasm', published by the Institute of Medicine in the early 90's drew attention to the gap between what we know and what we do [121]. The nature of the problem is described as one of overuse, misuse and underuse of health care services. In essence, the health care delivery system has fallen far short in its ability to translate research into practice and policy, and to apply new technology safely and appropriately [121]. A major implication from this observation is that patients don't always get safe and effective healthcare; second, much of biomedical, clinical and health research investment is wasted. Important knowledge-practice gaps that have significant adverse effects on the population health and social welfare, and the economic productivity of these countries have been reported globally in both primary care and specialty-provided care and in care provided by all disciplines [122]. Up to 30 to 40% of patients do not get treatment of proven effectiveness, 25% receive care that is not needed or potentially harmful [123, 124]. Such gaps between research evidence and clinical practice can lead to wide geographic variations in the use and quality of health care services [123-127].

How can we do better?

While much has been done to improve the creation of evidence-based knowledge, approaches to changing clinical practice are more often based on beliefs than on

scientific evidence [128]. As a consequence, Grol argued in the late 90's that '*Evidence based medicine should be complemented by evidence based implementation*' [128]. A recent overview of the rapidly developing field of knowledge translation research, the science of moving research into practice and policy, suggests the research community is rising to meet Grol's challenge [129].

What is Knowledge Translation (KT)?

Closing the research-practice gap involves changing clinical practice, a complex and challenging endeavour of KT. The Canadian Institutes of Health Research (CIHR) definition of KT is: '*a dynamic and iterative process that includes synthesis, dissemination, exchange and ethically sound application of knowledge to improve the health of Canadians, provide more effective health services and products and strengthen the health care system*' [130]. The science of KT research draws from a variety of behavioural and social science disciplines and employs new approaches and methods [111]. Though KT research has gained momentum in recent years, much remains to be done to effectively translate research activities targeting healthcare professionals and consumers, and even more so for approaches targeting healthcare policy makers and senior managers [105]. Specifically, research is needed: 1) to address the complex process of bridging research and practice in a variety of real-world settings, and 2) to conduct research that balances rigor with relevance and employs study designs and methods appropriate for KT research.

Need for theory-based complex interventions

«Findings from high quality clinical and health services research will not change population outcomes unless health care systems, health care organizations and health care professionals adopt them in practice.» [131]

Current evidence suggests that the impact of interventions to change professional behaviour is variable and, on average, the effect size is unusually no more than 10% on selected outcomes [132]. Despite the apparent advantages of applying theory to interventions [133, 134], a substantial portion of studies fail to explicitly apply or test theories [135]. Given this absence of a theoretical underpinning of interventions to improve care, it is difficult to interpret why chosen strategies were effective or ineffective. Furthermore, as the effectiveness of interventions appears to vary across different clinical problems, contexts and settings, the choice of strategies (i.e., interventions) to improve practice and patient outcomes should be closely linked to the reasons why practice variations exist and to barriers to knowledge uptake [136-140]. Designs and evaluations of theory-based complex interventions (i.e., interventions involving many interacting components) are increasingly recommended for studies aiming to implement evidence into practice [133, 141, 142].

Thesis theoretical framework

The limited success of current strategies to improve patient care have resulted in an increasing recognition that the development, evaluation and implementation of complex interventions to improve care should be guided by conceptual models or frameworks and behavioural theories to better understand the process of change [133]. An understanding of the theoretical assumptions and hypotheses behind these factors is necessary, as it enables the consideration of theory-based interventions for quality improvement [143]. Graham et al. undertook a critical analysis of conceptual frameworks for planned change to understand the theoretical underpinning of knowledge translation [144]. Based on previous work [109], this model adopted by the Canadian Institutes of Health Research (CIHR) illustrates how steps, actions, and factors interconnect in an iterative fashion [145]. The model helps conceptualize pathways to changing professional behaviour to improve health (Figure 1). The action phase (cycle) is derived from planned-action theories, frameworks, and models. The cycle may be thought of as an iterative process leading to implementation or application of knowledge (funnel).

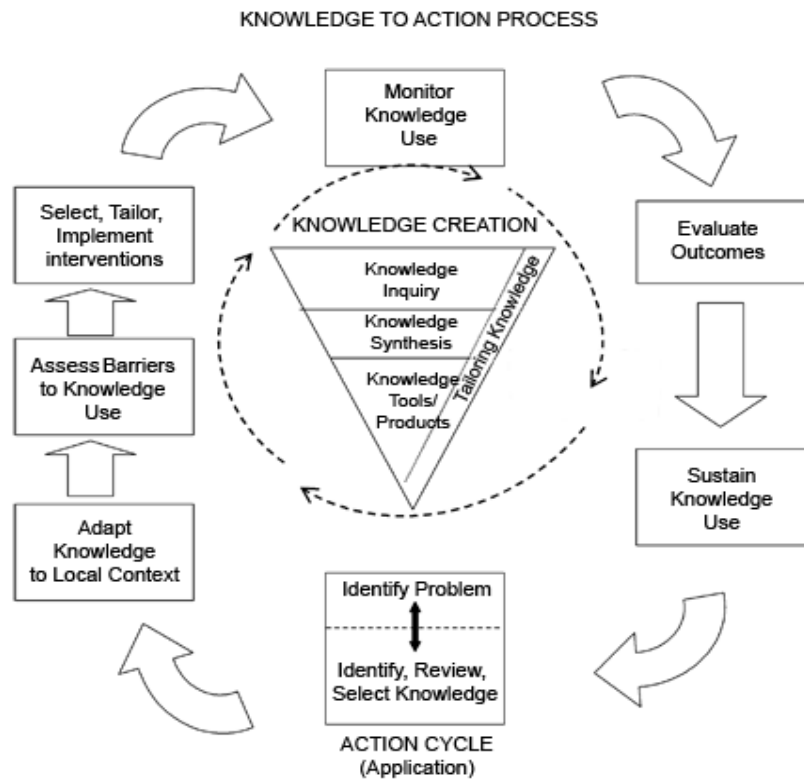


Figure 1. The Knowledge-to-Action process developed by Graham et al. (2006). The funnel represents the knowledge creation, and the cycle the application of knowledge (action)

The following is a brief overview of recommended steps to address knowledge-practice gaps including problem identification, selection of the research (knowledge) relevant to the problem, and context analysis. These steps can inform of strategies or interventions to narrow the research-practice gap [145, 146].

Problem identification

Assessing research-practice gaps

To improve the quality of care, we first need to assess current care in a simple, reliable way [147]. Determining the size and nature of the research-practice gap may be carried at the care provider-level (interviews, observations, chart audits) or population-level (administrative and clinical database) [147]. Administrative data are readily available, inexpensive, and cover large populations [148]. Claims databases, used for administering and reimbursing healthcare services, can help identify inappropriate use of tests and treatments. While large databases of services provided by chiropractors are not widely available in Canada, population level assessment of research-practice gaps may be conducted within large American Provider Networks.

Prioritizing research-practice gaps to target

There are numerous research-practice gaps, and one must be selective when choosing which ones to target. Ensuring existence of a strong evidence base for the need for change is important before expending substantial resources on implementation of evidence-based interventions [149]. The burden of disease, morbidity, quality of life and related costs should also be considered [147]. Appropriateness of imaging was recently defined in terms of expected net health outcome attributable to diagnostic imaging tests applied in specific clinical scenario, expressed as incremental quality-adjusted life years [150]. Spine x-ray ordering is clearly an important area to target considering: (1) the significant burden of neck and back pain [1-8]; (2) low prevalence of serious underlying condition that would require immediate medical attention [84]; (3) strong evidence that lumbar imaging for low-back pain without indications of serious underlying conditions

does not improve clinical outcomes [69]; (4) related costs of imaging [18-22]; and (5) persistent overuse and misuse of imaging services in the primary care setting [27, 42-45, 47].

Selecting the research relevant to the problem

The next step of the cycle involves selecting relevant research to address the problem. The Diagnostic Imaging Guidelines for Adult Spine Disorders (DIGASD) were developed to assist clinical decision-making and allow more selective use of imaging studies by chiropractors and other primary health care professionals [151]. Although these guidelines were released in 2008, recent systematic reviews [69, 85], best evidence synthesis [31, 81], and national guidelines [29, 152, 153] still support key recommendations for limited spine imaging of non-specific neck and back pain. Online summaries of guidelines are provided to ease application [72, 154].

Adapt knowledge to local context

Research evidence including CPGs may be adapted by individuals or groups as they make decisions about the value, usefulness, and appropriateness of particular knowledge to their setting and circumstances [155]. One example is the formal process used by a large chiropractic provider network to adapt the DIGASD [156].

Context analysis

Assessing barriers and facilitators to knowledge use

Assessments of barriers to uptake may help more effectively address practice gaps. Cabana identified over 250 barriers to implementation of guidelines by physicians [119]. Among these, six primary barriers related to individual providers (lack of awareness, lack of familiarity, lack of agreement, lack of self-efficacy, lack of outcome expectancy, and inertia of previous practice), while factors associated with patients, guidelines and the practice environment constitute external barriers [157]. However, factors influencing guidelines implementation likely varies across contexts and settings [117]. Very few studies have systematically assessed barriers to behaviour change among North American chiropractors.

Identifying modifiable behavioural determinants

Since implementing guidelines often require clinicians to change their behaviour, it may be helpful to base implementation interventions on explanatory models explicitly concerned with behaviour change [143]. Identifying modifiable factors, derived from psychological models, associated with the decision to perform a specific behaviour may provide an empirically-supported, theoretical basis to design interventions to favour the adoption of evidence-based practices. Very few studies have explored the usefulness of theoretical constructs among chiropractors [158] and, to my knowledge, no such studies have been conducted among North American chiropractors.

Select, tailor and implement intervention

The next phase is about planning and implementing interventions to promote clinician's adherence to evidence-based practice. Designing interventions to change professional behaviour involves a sequential approach in several steps from problem identification, assessment of barriers to change, identifying theory-based factors that underlie clinical practice, mapping identified factors to evidence-based behaviour change techniques, and selecting a format suitable for delivery of an intervention [159-161]. A conceptually similar process has been described to address physicians overuse of x-rays [158].

Monitoring, evaluating and sustaining knowledge use

Once the implementation interventions have been launched, knowledge/research utilization should be monitored over time, and impact of new strategies/interventions on clients/patients, practitioners and systems formally evaluated using valid tools [162]. This phase can be used to determine whether the intervention has been sufficient to bring about the desired change or whether more of the same or new interventions may be required.

Using theories to improve care

While the *Knowledge to Action* model helps us think through important steps to consider in developing a KT strategy, it offers little specific guidance at each step. The explicit use of theory can provide a generalized framework for interpreting and predicting professional behaviour and health impacts from various initiatives, and can help design interventions and evaluate potential causal mechanisms [138, 163]. A *theory* is “a coherent and non-contradictory set of statements, concepts or ideas that organises, predicts and explains phenomena, events, behavior, etc.” [164]. Psychology theories have been successfully applied to the maintenance and change of health-related behaviours such as smoking cessation, condom use, exercise and dietary practices, and to investigate the behaviour of health care professionals (prescribing antibiotics for uncomplicated sore throat, identifying factors predictive for ordering spine and intra-oral radiography) [159, 165-169]. Psychology theories may be categorized as either descriptive or explanatory theories [108, 170]. Although descriptive theories can be used to anticipate situations and processes, these theories are less helpful to explain what determines change or to identify non-modifiable determinants such as age and intelligence [171]. Explanatory theories help describe the reasons why a problem exists, and investigate hypotheses and assumptions about the causes, effects, and factors describing success (or the lack thereof) in improving health care. Furthermore, explanatory theories may be differentiated according to ecological level, individual professional, societal setting, and organizational, political and economical context [143]. Problems, behaviours, target groups, cultures and contexts of practices are numerous and varied, and not all these factors can be addressed within one theory or model of change [170]. Furthermore, the complexity of implementing changes to improve patient care cannot be explained from a single perspective; different approaches to

implementation often need to be integrated and tailored to the target group [111]. This thesis employs psychological theories to help explore why inappropriate use of spine x-rays may be occurring among North American chiropractors, and what theoretical constructs can be targeted for change. The following is a brief overview of the theoretical framework and psychological models of behaviour change used in this thesis.

Theoretical Domain Framework

Psychological theories to explain behaviour change are numerous, and many share overlapping constructs [110, 133, 143, 170, 172-174]. In addition, a method for identifying which theories are relevant to a specific problem in a particular setting or context is lacking. To maximise the accessibility and usefulness of psychological theories to researchers involved in evidence-based practice implementation, Michie et al. undertook conceptual mapping of 128 explanatory constructs drawn from the 33 psychological theories [175]. The Theoretical Domain Framework was developed to investigate determinants of specific clinical behaviours and thus may inform the design of interventions to change professional behaviour (Appendix 1). A domain is defined as encompassing a set of similar theoretical constructs. Interview questions corresponding to each domain provide a guide to relevant explanations of current professional and organizational behaviours and key prompts to behaviour change. Using the proposed questions to explore a specific behaviour ensures that no important domain is overlooked. These TDF questions may be adapted to explore the views of chiropractors on how best to manage patients presenting with spine disorders, and to inform them of potential barriers and facilitators toward implementing a diagnostic imaging guideline. A methodology for coding the theoretical domain interviews is not provided with the TDF. A

data analysis and management protocol was recently suggested to ease the process [176].

Psychological models of behaviour and behaviour change

Since implementing guidelines often require clinicians to change their behaviour, it may be helpful to base implementation interventions on explanatory models explicitly concerned with behaviour and behaviour change [143]. Key TDF domains can be used to inform the development of a theory-based predictive survey to explore factors that underlie clinical practice to identify the processes, or theoretical constructs, that are important in current patterns of care, and therefore should be the appropriate target of an implementation intervention [171]. Mid-level theories that have been rigorously evaluated in other settings, that explain behaviour in terms that are amenable to change, and that include non-volitional components (assumes that individuals are not always in complete control over their actions) may be used to inform the development of survey questionnaires [174, 177, 178]. Most of these theories afford intentions a key role in the prediction of behaviour [173]. Reviews have demonstrated that there is a reliable, albeit not perfect, relationship between the intention of performing a specific behaviour and the behaviour itself [165, 167, 179-182].

Rationale for the thesis

The significant burden associated with spine disorders, compounded by suboptimal management, highlights the need for rigorous research to promote the uptake of evidence-based practice in the primary care setting [183]. High quality CPGs recommend against routine use of spine x-rays for non-specific back and neck pain. Strategies to improve the use of CPGs have had limited and varied effects to date [102]. By themselves, CPGs cannot overcome the multitude of barriers to clinician adherence [119]. Several factors, involving the clinicians, patients, and the health care environment, influence decision making or clinical behaviours. Competing beliefs and other factors such as environmental issues can prevent practitioners from using best evidence. Ongoing effort is needed to identify these modifiable determinants of clinicians' test ordering to encourage evidence-based practice. Given the very slow pace of converting evidence into routine practice (between 1 to 2 decades) [184], KT has emerged as an important consideration to promote evidence-based practice [129]. Knowledge Translation (KT) research is the scientific study of the determinants, processes and outcomes of dissemination and implementation [129]. To date, very little knowledge translation research has addressed research-practice gaps in chiropractic. Only one ongoing cluster trial evaluated Australian chiropractors' compliance with a CPG to reduce lumbar x-rays for acute lower back pain (LBP) [185]. The effect of dissemination of diagnostic imaging guidelines on the behaviour of North American chiropractors has not been adequately studied yet.

This thesis explores different aspects of the path from research to the practitioners' uptake of evidence into professional practice. A sequential mixed methods was selected

to add breadth and scope to this project and to compensate for weaknesses of each method [186].

Purpose and objectives

The overall aim of this thesis is to understand determinants of variations and overuse of spinal imaging among chiropractors. The long term goal is to improve guideline adherence and the selective use of spine x-rays for chiropractic patients presenting with spine disorders. The specific objectives of this thesis are:

1. To describe practice patterns and baseline rates in spine x-ray ordering among a group of chiropractors enlisted in a provider network in the US.
2. To evaluate the impacts of the passive guideline dissemination among these providers.
3. To identify barriers and facilitators to the implementation of these recommendations among North American chiropractors using a theoretical framework.
4. To assess the relevance of identified factors thought to be most likely to be effective targets for change and identify which theoretical constructs predicted a change in clinical practice.

Study setting

The thesis work in the US was undertaken in collaboration with the American Specialty Health Network (ASH), a health maintenance organization (HMO) that wanted to address inappropriate use of x-rays within its quality improvement activities. ASH offers complementary and alternative health care coverage in each of the 50 states, to over 13 million American members. Coverage includes chiropractic services with nearly 15,000 care providers. Benefits of a collaboration with ASH includes the possibility to develop, implement and evaluate a theory-based intervention within a unique knowledge transfer laboratory-like setting, as well as the possibility of ongoing work leading to a definite implementation trial.

We undertake collaborative research with ASH to address Objectives 1 to 3.

We also addressed Objective 3 and 4 in the Canadian settings, allowing a comparison of US and Canadian determinants (Objective 3). Considering that nearly two third of chiropractors practice within Quebec and Ontario, and the observed wide regional variation in x-ray utilization between the two provinces [36], these appeared well suited to explore professional behaviour among Canadian chiropractors. Overall study findings may serve to design, implement and evaluate interventions to change professional practices. Such study may be replicated in the Canadian setting.

Thesis structure and short summary of each chapter

The thesis comprises four individual studies (chapters 2-5), each of which resulted in a paper for publication.

Chapter Two: Practice patterns in spine x-ray ordering practice

Chapter Two describes baseline rates and variations in x-ray ordering practice among a group of American provider network chiropractors. The results are presented in the format required for submission to the *Journal of Manipulative and Physiological Therapeutics*.

Chapter Three: Impact of passive guideline dissemination

In this chapter, I present the results from the quasi-experimental study in which we assessed the impact of web-based dissemination of guideline recommendations among chiropractors enlisted in an American provider network. This chapter is presented in the format submitted to the journal *The Spine Journal*.

Chapter Four: Understanding spine x-ray ordering practice

This chapter is a reproduction of the publication of the focus group study using the Theoretical Domain Framework to identify factors likely to influence compliance with diagnostic imaging guideline recommendations for spine disorders among chiropractors in North America. The chapter is presented in the format published in *Implementation Science*.

Chapter Five: Predicting spine x-ray ordering practice

In this chapter, I present the results of the predictive studies. The aim was to identify theoretical factors associated with the decision to order spine x-rays for low back pain in adults. This chapter is presented in the format required for submission to the *Implementation Science*.

Chapter Six: Discussion and Conclusions

The final chapter of this thesis (Chapter 6) contains: (1) a summary of the findings from each of the four studies, (2) key strengths and limitations of the research, (4) a description of the implications of the research on population health and practice, and (5) the next steps in my program advancing the science of knowledge translation.

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CHAPTER TWO PRACTICE PATTERNS IN AN AMERICAN PROVIDER NETWORK

“Evidence is the basis for the message – but not the message itself”

Knowledge transfer conference working

Practice patterns in spine x-ray utilization among chiropractors enlisted with a provider network offering complementary care in the United States: A descriptive study ¹

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Abstract

Background: Non-specific back pain is associated with high x-ray utilization rate in primary care, yet current evidence suggests routine imaging of the spine is unnecessary.

Objectives: To describe current practice patterns in spine x-ray utilization among chiropractors enlisted in an American provider network.

Methods: Cross-sectional analysis of administrative claims data. Survey data containing provider demographics were linked with routinely collected data on spine x-ray utilization and patient characteristics aggregated at the provider level. We calculated rates and variations of spine x-rays over 12 month. Negative binomial regression were performed to identify significant predictors of high x-ray utilization and to estimate the associated incidence risk ratio.

Results: Complete data for 6,946 chiropractors and 249,193 adult patients were available for analyses. In 2010, claims were paid for a total of 91,542 new patient exams and 23,369 spine x-rays (including 17,511 ordered within 5 days of initial patient exam). The rate of spine x-rays within 5 days of an initial patient visit was 204 per 1000 new patient exams. Significant predictors of higher x-ray utilization rates included: practicing in the Midwest or South US census regions, practicing in a urban or suburban setting, chiropractic school attended, and being a male provider in full time practice with over 20 years of experience.

Conclusion: Chiropractic school attended and practice location were the most influential predictors of spine x-ray utilization among network chiropractors. Knowledge gained may inform the development and evaluation of a tailored intervention to reduce x-ray use.

MeSH Key Words. Chiropractic, Delivery of Health Care, Practice Patterns, Quality Assurance, Health Care, Radiography.

Running Head. X-ray utilization practice in a provider network

Introduction

Gaps between research evidence and clinical practice can lead to important variations in the use and quality of health care services¹⁻⁴. Information on evidence-practice gaps is necessary to set goals and develop quality improvement strategies to change process of care and improve patient outcomes⁵. One example of a persistent knowledge-practice gap is the overuse of diagnostic imaging for spine disorders^{6,7}. Data on chiropractors' utilization of spine x-rays is sparse with wide variability reported in the literature, with figures ranging from 12-26%⁸⁻¹⁰ to well over 55%¹¹⁻¹⁵ in North America.

The high prevalence of neck and back pain results in enormous social, psychological, and economic burden¹⁶⁻¹⁸. In North America, most seeking help for their pain consult medical doctors or chiropractors¹⁹⁻²³ and many still undergo routine spinal imaging^{7,12,24}. Current evidence and clinical guidelines suggest that routine radiography is unnecessary during the initial evaluation of non traumatic neck and back pain unless specific clinical indicators (red flags) are present^{25,26}. Inappropriate use of spine imaging has a number of potential adverse outcomes, including inefficient and potentially inappropriate invasive diagnosis and subsequent treatment²⁷⁻³⁰, unnecessary patient exposure to ionizing radiation^{6,31-33}, increased waiting time for treatment; added costs and poor utilization of human resources²⁸.

With the exception of the National Board of Chiropractic Examiners³⁴, few studies have attempted to describe practice profiles of chiropractors in the United-States and those that have used data collected prior to 1995^{23,24,35,36} that may no longer reflect current practice. Even fewer studies have assessed utilization in established chiropractic practice networks³⁷⁻³⁹, and these used convenience samples and therefore may not be representative of the population. Provider networks (PN) refer to private

organizations that provide health care for health plans in the US with coverage for specific services by enlisted care providers ⁴⁰.

This study aimed to describe current practice patterns and variation in spine x-ray utilization among chiropractors enlisted with the American Specialty Network (ASH) (a large PN). Our specific objectives were to: (1) to describe provider, practice, and patient characteristics within all regions served by the PN, (2) to determine the baseline rates and variations of spine x-ray claims over a 12 month period, and (3) to identify professional and practice-related determinants of high spine x-ray utilization.

Methods

Design

A cross-sectional study was conducted with data obtained from the PN. Data on the number of spine x-rays ordered by contracted chiropractors were linked with survey data on demographic and enrolment information chiropractors completed prior to registering with the PN. We first performed descriptive analyses on survey data. Baseline rates and variations of spine x-rays occurring within all 50 states were estimated at the care provider level for the year 2010. Regression analyses were conducted to assess factors likely to explain x-ray utilization rates for the 12 month period.

Population

Participants were selected from the PN administrative databases among a target population of 15,429 chiropractors. Sampling was limited to contracted providers who received payment for at least one claim submitted in 2010 for adults with spinal complaints (10,052 chiropractors). Consecutive patients over the age of 18 were

included if they were receiving care for complaints of neck, back or low back pain.

Duplicate services and billing, and Medicare contracts were excluded (Figure 1 displays the flow of participants).

Setting

The PN provides complementary health care networks for health plans across the US, and includes over 15,000 chiropractors from 50 states ⁴⁰.

Data sources

Two administrative databases were linked: The PROvider Maintenance Information System (PROMIS) database which consists of demographic, practice and provider characteristics extracted from surveys questionnaires completed by chiropractors prior to enrolment with the PN, and Structured Query Language (SQL) which contains clinical and claims data for continuously enrolled patients aggregated at the care provider level. Data were extracted from SQL about claims made between January 1st, 2010 and December 31st, 2010 from the PN administrative claims database. Diagnostic and procedure codes are classified under the *International Classification of Disease, Ninth Revision (ICD-9)* ⁴¹ and the *Current Procedural Terminology (CPT), Fourth Edition* ⁴². Complete datasets were extracted at the provider level for the year 2010, including: (a) number of 'established patients' defined as insured individuals using chiropractic services for which there was at least one allowed paid service during the reporting period; (b) number of 'new patient exams' for complaints of spinal disorders were extracted separately to estimate chiropractors' tendency to perform immediate spine x-rays; (c) claims data for spine x-rays (cervical, thoracic, lumbar and full spine x-rays); and (d) claims data for spine x-rays ordered within five (5) days of initial patient visit (same anatomical regions) were extracted for the entire study period. Each service

for a radiographic exam as identified by the applicable CPT code was counted as an x-ray study. No distinction was made among the different types of radiographs or number of radiographs associated with each study. The reliability of data extraction process were assessed by two study investigators (AB, SH) on two occasions (February and June 2011) at the PN head office in San Diego by comparing randomly selected cases with the original dataset.

Practice, provider, and patient characteristics (predictor variables)

The following practice characteristics were examined: geographical location (state), practice setting (urban, suburban or rural), office type (pro/medical health care building, office building vs. free standing clinic, home, gym or other), and practice type (solo, group, employed).

Provider characteristics included: age, gender, date of licensing, full time (≥ 25 hours/week) or part time (1-24 hours/week) employment, number of patients treated per hour, and number of years since contracted with PN. Chiropractic school attended was included to investigate a potential association with adherence to evidence-base guidelines since inclusion of evidence-based principles in North American chiropractic curricula is variable⁴³⁻⁴⁵.

Patient characteristics aggregated at the provider level, included: number of patients per chiropractor, age (18-35, 36-49, 50-65, and over age 65), and gender (male/female).

Outcome Measure

The main outcome measure, hereafter referred as 'immediate spine x-rays', was the mean number of spine x-rays ordered within 5 days of initial patient visit per 1000 'new patient exams' for complaints of spinal disorders during the 12 months period.

Ethics

A data use agreement was signed by involved parties and ethics approval was granted by the Ottawa Health Research Ethics Boards.

Data analysis and management

Data extracted were downloaded into two SPSS files and then linked and analysed using SAS statistical software (version 9.2).

Descriptive statistics were used to examine the distribution of predictor variables. Practice, provider and patient profiles were grouped by states and census regions for comparison. To allow for direct comparison of x-ray utilization and patterns across census regions for the year 2010, raw counts were converted to rates of x-ray claims paid for spine x-rays (cervical, thoracic, lumbar and full spine) per 1000 patients per year.

Negative binomial (NB) regression analyses for highly skewed count data with over-dispersion (i.e., variance greater than the mean) were conducted to assess the association between x-ray utilization rates and explanatory variables using SAS GENMODE procedure.

Primary analysis

Binary predictors were dummy-coded with male providers' and free standing clinic (office type) coded as zero. In an effort to avoid selecting too many variables and over-fitting the data set, only those variables that were selected by backward stepwise procedure were eligible for entry into the regression analysis. Parameters were estimated by maximum likelihood ratio. All statistical tests were 2-tailed and statistical significance was set at $p < 0.05$. The significance of the regression models were

obtained by using a standard likelihood ratio test comparing each model's deviance to the deviance of a nested simple regression model for the outcome.

Sensitivity analysis

As data on patients referred for imaging at outside facilities (i.e., radiology centers or hospitals) were not available for review, a separate analysis was conducted on providers who reported having onsite imaging services. In addition, while claims for a 'new patient exam' on any individual patient could only be submitted once every three years for any specific complaint, x-ray claims could be submitted at anytime and any frequency. As a result, x-ray claims for a recurrence of a condition occurring within the three year period were submitted as an '*established patient*'. Separate analyses were conducted on '*spine x-ray utilization claim data per number of established patients*' to determine if the billing requirement influenced our main findings.

Results

Descriptive analysis

Cross-sectional analysis was carried out on 6,946 contracted PN chiropractors and their 249,193 consecutive unique adult patients (mean of 35.9 ± 53.9 per chiropractor), including 91,542 new patient exams (mean 13.17 ± 19.30 per chiropractor) for complaints of neck, back or low back pain. Practice, provider, and patient characteristics of the contracted PN chiropractors and those who indicated having onsite imaging services (N=4094) are displayed in Tables 1 and 2.

Table 3 displays claims data and main outcome measure for the year 2010. The mean rate of immediate spine x-rays (i.e., spine x-rays within 5 days of initial patient visit per 1000 new patient exam) was 204 ± 422 per 1000. X-ray utilization rates were higher

among contracted PN providers who reported having onsite imaging equipment (329 ± 497/1000).

Table 4a reports the regional variation in x-ray utilization rates (means and standard deviations per 1000 patients) for states with over 100 PN contracted providers. The lowest mean rates of immediate spine x-rays were observed in the state of Oregon (100 ± 250/1000), followed by Pennsylvania (150 ± 370/1000), and California (160 ± 290/1000). Three fold higher rates were observed in the states of Ohio (410 ± 700/1000), and Georgia (470 ± 560/1000). Variations in x-ray utilization rates by census regions are presented in Table 4b.

Primary analysis

The data were right skewed with clumping at zero (i.e., over 70% of patients had not ordered x-rays at 12 months) and over-dispersed. We observed no important correlations between predictor variables. Selection of the regression models are presented in Additional file 1.

Table 5 displays the summary findings of the final negative binomial regression models predicting immediate x-ray use. Incidence rate ratios (IRR) were obtained by exponentiation of the regression coefficients. Table 6 presents the IRR and associated 95% confidence intervals (CIs) for each variable.

Practice characteristics: Chiropractors practicing in South and Midwest census regions were more likely to have respectively 1.89 and 2.21 times higher rates of immediate x-rays compared with those in the West (Wald $X^2=18.89$, $df= 3$, $P=<.0001$, IRR=2.21, 95% CI=1.56-3.19). Providers working in the suburban and urban setting were more likely to have respectively 1.21 and 1.23 times greater spine x-ray utilization rates compared to those in rural settings. In addition, practicing in a free standing clinic

increased the likelihood of ordering spine x-rays (Wald $X^2=6.72$, $df=1$, $P=0.009$, IRR=1.16, 95% CI=1.04-1.30) compared to being in a professional or medical building. In contrast, solo providers tended to order fewer x-rays than those employed by a colleague (Wald $X^2=13.41$ $df=2$, $P=0.002$, IRR=0.63, 95% CI=0.49-0.80).

Provider characteristics: Compared to the University of Western State Chiropractic College, graduates from Parker, Palmer (PCC), North-Western, Life East and Texas had the higher x-ray utilization rates (IRR ranging from 2.3 to 3.01), followed by graduates from New York (NYCC), Palmer West, Life-West, Southern California University of Health Sciences and Cleveland (IRR ranging from 1.38 to 1.73). Providers in full time practice were also more likely to have higher x-ray order rates (Wald $X^2=8.51$, $df=1$, $P=0.003$, IRR=1.25, 95% CI=1.07-1.45), as were chiropractors with over 20 years experience. X-ray utilization rates were 1.34 times higher for male chiropractors (Wald $X^2=27.34$, $df=1$, $P<0.001$, IRR=1.33, 95% CI=1.22-1.42). Post-hoc analysis found significant interactions between: providers in full time practice and practice volume ($X^2=93.14$, $p<0.001$), school attended and years in practice ($X^2=164.37$, $p<0.001$), and formal training and census region ($X^2=179.72$, $p<0.001$). Adding the variable 'Onsite imaging' as a predictor would have resulted in a tenfold increase in spine x-rays (Wald $X^2=1030$, $df= 1$, $P=<.0001$, IRR=11.21, 95% CI=9.67-12.99).

Patient characteristics: No difference was observed for practice volume, patient age or gender.

Sensitivity analysis

We conducted separate analyses on 4094 contracted PN providers who indicated having onsite imaging services. Similar factors (census region, school training, practice setting and practice type) explained x-ray utilization among owners of x-ray equipment

(Table 5). Of interest, providers contracted for over 20 years had higher spine x-ray utilization rates (Wald $X^2=7.8$, $df=3$, $P<0.005$, $IRR=1.61$, $95\% CI=1.13-2.22$). Providers' gender, office type, years in practice, and professional employment did not explain x-ray utilization rates in this subgroup. Separate analyses were also conducted on the *number of spine x-ray claims per number of established patient* on 6946 contracted PN providers. Similar factors explained x-ray utilization rates (Table 5).

Discussion

This study examined real world chiropractic practice patterns and variations in spine x-ray utilization in a Provider Network (PN). Negative binomial regression model suggested that x-ray utilization was primarily associated with practice location (census region and urban or suburban setting), practice type (free standing clinic) and chiropractic training. Male providers and those with over 20 years experience were also more likely to order spine x-rays.

During this study period, the PN providers were credentialed using standardized process. The privileging process screened providers applying to the PN who did not appear to have clinical protocols consistent with professionally recognized standards of practice. PN providers must adhere to specific organizational policies and guidelines that are based on professionally recognized standards of practice and approved by actively practicing peer providers. As a result, one would expect practice profiles to be very different from chiropractors across the US. However, available data from the 2010 practice analysis of chiropractic conducted by the National Boards of Chiropractic Education (NBCE)³⁴ and from a descriptive analyses of chiropractic in North-America²³,⁴⁶ suggests our population was generally representative of licensed chiropractors, practices and patients across the US. Unfortunately, these studies did not collect data on

x-ray utilization. Small percentage differences observed between characteristics (practice, provider, and patient) of all contracted PN chiropractors and those who indicated having onsite imaging services (N=4094) are unlikely to be clinically meaningful (Table 1 and 2).

The observed x-ray utilization rate among chiropractors was 20.4%, with important regional variations ranging between 10% in the state of Oregon to 47% in Georgia (Table 4a). Although appropriateness of x-rays utilization could not be addressed as the available administrative data lacked detailed clinical information (presence of red flags, co-morbidity, and disease severity), observed variations in health service utilization in this PN seem unwarranted considering the risk–benefit ratio. Appropriateness of imaging test may be defined as the difference in outcomes between empirical treatment (no diagnostic imaging procedure) and treatment informed by the results of an imaging test, when applied in a specific clinical scenario, expressed in quality-adjusted life years⁴⁷. The prevalence of serious underlying conditions (such as cancer, infection, or cauda equina syndrome) that would require immediate medical attention is very low⁴⁸. Further, lumbar imaging for low back pain does not improve clinical outcome in the absence of clinical indicators of serious underlying condition²⁵. It is also important to remember that x-ray is not a sensitive modality for detection of early cancer or infection⁴⁸. The problem of overuse also persists among general physicians. Recent analysis of claims data from 40 self-insured employers in the US indicated that general practitioners lumbar spine x-ray use was 32.2%, with 60% of patients receiving x-rays on the initial visit⁷. Additional efforts aiming to change professional behaviour to improve guideline adherence and reduce immediate imaging tests are needed⁴⁹.

Practice characteristics

Providers in the South and Midwest had higher utilization. This is largely explained by a few states (Georgia, Arizona and Utah, and Ohio) with high x-ray utilization within these regions. Our finding parallels those of Isaacs et al. (2004) who found higher spine x-ray utilization among physicians in metropolitan compared to rural areas⁵⁰. Solo PN chiropractors had slightly lower x-ray utilization rates than those working as associates. This is may be because chiropractors are most likely to start out as associates before becoming sole proprietors⁵¹. Providers in free standing clinics also had higher utilization rates. Those working in multidisciplinary settings (professional and medical building) may be more inclined to adopt an evidence-based practice⁵².

Provider characteristics

Providers trained at Life East, Parker, Palmer (PCC, PCCF), Sherman, Cleveland, Texas, and North-Western (NWHSU) chiropractic colleges were more likely to have high x-ray order rates (IRR > 1.5). With the exception of Texas college and possibly NWHSU, our findings generally support the assumption that graduates from these colleges share lesser adherence to evidence-based principles⁵³. This is partly reflect by the frequent use of the term subluxation to describe the program curricula of several of these colleges⁵⁴. The subluxation concept is one of the most controversial ideas in chiropractic⁵⁵. The subluxation complex, a theoretical model of motion segment dysfunction of the spine that incorporates interaction of pathological changes in nerve, muscle, ligaments, vascular, and connective tissues⁵⁶, lacks sufficient evidence base to support it as a clinical entity⁵⁷. This concept is at the center of a paradigm difference (experiential vs. evidence-based practice) between many chiropractors and researchers, academic chiropractors and elected leaders⁵⁸⁻⁶⁰.

Providers in full time practice tended to order x-rays more frequently. An interaction with practice volume ($X^2=93.14$, $p<0.001$) suggests exposure to more (diverse) cases is a plausible explanation. As with physicians, older and more experienced clinicians tended to have lower adherence to standards of care⁶¹ and higher x-ray utilization rates⁵⁰. An interaction was also found between school attended and years in practice ($X^2=164.37$, $p<0.001$) suggesting that chiropractors continue practicing as they were initially trained. This underlines the long lasting influence of formal training and the challenges in keeping up to date.

The limited set of included variables for patient characteristics (age, gender, practice volume) did not appear to explain x-ray utilization in this group. While clinical characteristics to determine appropriateness would have been useful, these variables were not available for analysis.

Sensitivity analysis

Data on patients referred for imaging at outside facilities (i.e., radiology centers, hospitals) were not available for this study. Separate analyses were conducted to explore whether the results were sensitive to systematic undercounting of x-rays by chiropractors without on-site imaging. While differences in characteristics were observed between providers with and without onsite imaging, these were small and unlikely to be clinically meaningful. Furthermore, similar factors (census region, school training, practice setting and practice type) explained x-ray ordering behaviour among owners of x-ray equipment, suggesting inclusion of all contracted providers in the primary analysis was a sensible approach. Despite billing requirements allowing for reimbursement of new patient exams once every three years, the same factors predicted both *immediate spine x-rays* (x-rays claims within five days of initial visit per new patient exam) and

'spine x-rays per established patient' (x-rays ordered over the 12 month period), suggesting our results were robust.

Implications for research

Further studies should aim to reduce inappropriate use of spine imaging and better quantify and explain small area variations observed⁶². Guideline dissemination and implementation strategies can encourage practitioners to conform to best practices and lead to improvements in care⁶³⁻⁶⁵. However, there is a need for high quality studies evaluating the effectiveness and efficiency of Clinical Practice Guidelines (CPG's) dissemination and implementation strategies⁶⁶. Identifying determinants of behaviour change likely to influence the implementation of practice guidelines is a recommended initial step to tailor interventions to improve patient care^{67, 68}. In addition, several organizational factors can influence guidelines adherence including work structure, financial and material contexts, work-related activities, training opportunities and communication, work culture, type of management and policies⁶⁹. Explaining inappropriate use of imaging and inter-regional (and inter-professional) variation should include provider-related factors (e.g., routine use of x-ray driven techniques, beliefs about the etiology of disease), organizational (objective predictors where feasible, types of payment structures, training opportunities, influences from communications and policies), and socio-cultural determinants (professional affiliations, continuing education attended). For instance, compensation for services varies by State and by Health Plan. Future studies should aim to explore service reimbursements as strategies to reduce x-ray ordering practice in PN settings. Physicians with onsite imaging equipment and owners of imaging facilities tend to have lower guideline adherence and to overuse imaging⁷⁰. Post-hoc analysis indicated that adding the variable 'Onsite imaging' as a

predictor would have resulted in a tenfold increase in immediate spine x-ray utilization rate (Wald $X^2=1030$, $P<.0001$). This suggests self-referrals may be equally problematic in chiropractic. Future studies should aim to capture chiropractors' x-ray referrals to medical facilities.

Implications for policy makers

Developing effective strategies to reduce inappropriateness of health care delivery and optimize diagnostic test ordering behaviour have become major concerns^{5, 71}. Although evidence-based diagnostic imaging guidelines are available, chiropractors remain divided on whether current guidelines recommendations for spine imaging apply to them^{14, 72, 73}. Rates among PN chiropractors in Georgia and Ohio were over twice as high as the national rate. Choice of practice location is determined by a range of personal, occupational and environmental factors⁷⁴. The interaction between formal training and census region suggests chiropractic school attended likely plays a role in deciding where chiropractors choose to establish practice. In a related study, focus group interviews among PN providers suggested formal training was an underlying factor of x-ray utilization practice many years later⁷⁵. Strategies to reduce inappropriateness of x-ray utilization should consider exploring views from instructors of radiology department within chiropractic schools who train future professionals and are key players in updating program curriculums.

Quality improvement strategies in this PN setting may be more successful if interventions designed to overcome barriers to behaviour change targeted providers in metropolitan areas within identified geographical regions. Observed x-ray utilization rates may be partly attributable to specific PN Clinical Performance System (provider

tiering system) designed to improve guideline adherence and reduce x-ray use and may not reflect the rate of use in an unmanaged system.

Study limitations

Although our study had a number of strengths, including a large sample size, inclusion of all patient encounters for spine disorders by chiropractors contracted by one of the largest provider of complementary care network across the United States, and use of objective outcome measures, there are important limitations. This analysis is subject to the usual caveats when using administrative data with limited or absent clinical data⁷⁶. First, data were not collected for research and, therefore, did not include some variables that may be of interest. For example, the utilization rates were adjusted for age and sex but not for other confounding covariates such as health status and extent of health-care insurance coverage, two important determinant of health care utilisation⁷⁷. The appropriateness of x-ray utilization cannot be addressed as the available administrative data lacked detailed clinical information such as presence of red flags, co-morbidity, and disease severity. Further, rates of immediate spine x-ray utilization were likely underestimated for the following reasons: (1) claims for patients referred for outside films (e.g., medical imaging centers, hospitals) were not submitted to the PN. Sensitivity analysis suggested this was not a major problem however; (2) providers could only claim a new patient exam on any individual patient once every three years, which likely underestimated immediate spine x-ray utilization. Nonetheless, similar predictors explained x-ray utilization when controlling for this policy; (3) a majority of providers also billed other healthcare carriers (e.g., Medicare, Medicaid, Workers' compensation, Personal Injury, private insurance or other networks, had a cash business); (4) Nearly 20% of providers worked part time, and a small proportion were likely on disability,

holidays or retired in 2010; (5) underutilization of spine x-rays may well be a problem. However, it is unclear if MRIs or other tests were being substituted for undergoing x-rays; and (6) the study inclusion criteria '*contracted providers with at least one claim paid in 2010*' was not specific to spine related disorders.

Secondly, some self-reported practice and provider characteristics obtained through survey questionnaire (onsite imaging, chiropractic school, and mean number of treatments per hour) may have been outdated or have measurement error. The other predictor variables entered in the final model had fewer chances of bias as they were obtained through Zip codes used for billing purposes (practice location) or by PN administrative claim database (aggregated patient characteristic and outcome measures).

X-ray utilization rates would likely be higher had our data included the following three variables: claims submitted instead of claims paid, secondary diagnosis, and additional practice location. (1) While claims submitted by providers may be more representative of professional behaviour, reasons for denied payment (administrative or clinical) were not available. Therefore, rates accounted for claims paid; (2) Although some patients had more than one spinal complaint, only primary diagnosis was considered for inclusion; (3) only data from primary practice location could be collected, although some providers practiced in more than one site. Finally, error in measurement that systematically undercounts x-rays by chiropractors without onsite imaging may have occurred.

Conclusion

Despite available evidence-based clinical practice guidelines reinforcing the importance of selective use of spine x-rays, overuse of spine x-rays persists among

chiropractors contracted with one of the largest provider of complementary health care networks for health plans in the US. Findings suggest that rates of spine x-rays among these care providers are primarily associated with practicing in two census regions in the urban and suburban settings, and chiropractic school attended. Further investigations to better quantify observed variations and the nature of relationships between factors (structural, individual, organizational and socio-cultural), as well as to assess the effect of onsite imaging and provider tiers system are needed. Knowledge gained may inform the development and evaluation of quality improvement strategies.

JMPT highlights

- Overuse of spine x-rays and wide geographical variations persist among chiropractors contracted with one of the largest provider of complementary health care networks for health plans in the US.
- The main structural determinants of spine x-ray utilization were practicing in two census regions, in the urban or suburban setting, and chiropractic school attended.

Competing interests

The authors declare that they have no competing interests. A data use agreement was signed by ASH, the OHRI to avoid potential conflict of interest.

Contributors

AEB designed the study, analysed and interpreted the data, and drafted the manuscript.

JMG designed the study, revised the manuscript, and supervised the research group.

TR and AES designed the study and revised the manuscript. All authors read and

approved the final manuscript. SH contributed to the selection of variables, assessment of data accuracy and comprehensiveness of information, co-ordinated data extraction and transfer at the ASH head office in San Diego, interpreted the data, and revised the manuscript.

Additional file 1. Regression for count data with over-dispersion: Model selection.

Fig 1. Flow of participants

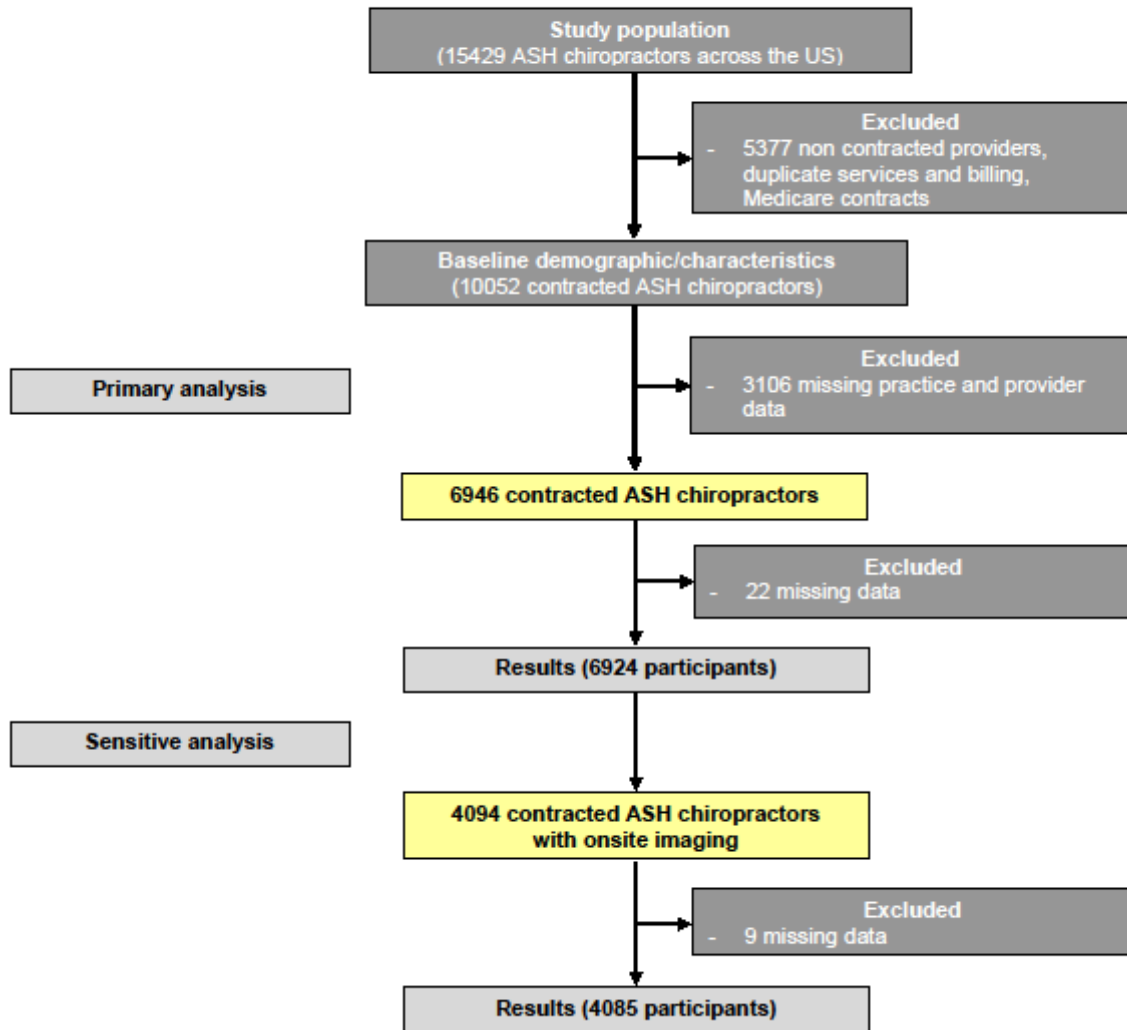


Table 1. Practice and provider characteristics of PN contracted chiropractors across the US compared to those with onsite imaging services

	Contracted providers	With onsite Imaging	X², P value
Practice characteristics	Population % (95% CI) N=6946	Population % (95% CI) N=4094	
Number of chiropractor as of Dec 31 th , 2010			
Practice location			(9.05, P=0.01)
Urban	45.5 (44.3-46.7)	44.7 (43.2-46.3)	
Suburban	24.9 (23.9-26.0)	26.3 (24.9-27.6)	
Rural	29.5 (28.5-30.6)	29.0 (27.6-30.4)	
Census Region			(218,0 <.0001)
Northeast (New England, Middle Atlantic)	33.7 (32.6-34.8)	27.8 (27.3-30.2)	
Midwest (East North Central, West North Central)	3.6 (3.2-4.1)	4.6 (3.9-5.3)	
South (South Atlantic, East South and West South Central)	13,0 (12.3-13.8)	16.9 (15.8-18.2)	
West (Mountain, Pacific)	49.6 (48.4-50.8)	49.7 (48.1-51.2)	
Practice type			(75.9, <.0001)
Solo	50.9 (49.8-52.1)	47.0 (45.4-48.5)	
Group	42.3 (41.1-43.5)	44.9 (42.4-46.5)	
Employed	6.7 (6.1-7.3)	8.1 (7.3-8.9)	
Office information			(124.1 <.0001)
Pro/medical building, educational institution	51.9 (50.7-53.1)	53.7 (52.2-55.2)	
Free standing clinic, home clinic, shopping center, health club, gym, other	48.1 (46.9-49.3)	46.3 (44.8-47.9)	
Provider characteristics			
Age (years)			(85.7, <.0001)
18-35	12.1 (11.3-12.9)	9.8 (8.9-10.7)	
36-49	46.1 (44.9-47.43)	44.6 (43.1-46.1)	
50-65	39.0 (37.9-40.2)	42.6 (41.1-44.1)	

> 66	2.8 (2.4-3.1)	3.1 (2.5-3.6)	
Provider gender			(128.7, <.0001)
Male	81.0 (80.1-81.9)	85.5 (84.4-86.5)	
Female	18.9 (18.1-19.9)	14.5 (13.5-15.6)	
Number of years in practice (licensed)			(152.2, <.0001)
< 5 years	43.8 (41.9-44.3)	5.4 (4.7-6.1)	
6-10 years	35.6 (34.5-36.7)	13.8 (12.7-14.9)	
11-20 years	19.9 (19.0-20.1)	31.9 (30.5-33.4)	
> 20 years	1.4 (11.4-17.1)	48.9 (47.4-50.5)	
Professional employment			(109.3, <.0001)
Full time (> 25 hours/wk)	81.7 (80.7-82.6)	85.7 (84.6-86.8)	
Part time (>1-24 hours/wk)	18.3 (17.4-19.3)	14.3 (13.2-15.4)	
Practice volume (patients treated per hours)			(360.8, <.0001)
1-2 patients/hour	9.4 (8.9-10.2)	5.7 (4.9-6.1)	
5 patients/hour	57.9 (56.8-59.1)	53.9 (52.4-55.5)	
8 patients/hour	26.5 (25.8-27.5)	32.5 (31.1-33.9)	
12 patients/hour	6.2 (5.6-6.7)	7.9 (7.1-8.7)	
Number of years contracted with the PN			(154.8, <.0001)
< 5 years	7.2 (6.6-7.8)	37.8 (36.3-39.3)	
6-10 years	15.8 (14.9-16.7)	36.6 (35.1-38.0)	
11-20 years	33.6 (32.5-34.8)	23.8 (22.5-25.2)	
> 20 years	43.4 (42.2-44.5)	1.8 (1.4-2.2)	
Chiropractic school attended (formal training)			(261.7, <.0001)
Sherman College/ Sherman Coll. of Straight Chiropractic	2.4 (2.1-2.8)	2.3 (1.9-2.8)	
Life University	13.9 (13.2-14.8)	16.9 (15.7-18.0)	
Life chiropractic College West	5.5 (4.9-6.0)	5.2 (4.5-5.9)	
Palmer College, Davenport (PCC)	14.2 (13.4-15.1)	16.6 (15.4-17.7)	
Palmer Chiropractic College Florida	0.2 (0.1-0.3)	0.2 (0.1-0.4)	
Palmer Chiropractic College West	7.7 (7.1-8.3)	7.1 (6.3-7.9)	
Parker College	2.4 (2.0-2.8)	2.6 (2.1-3.2)	
Pennsylvania	0.9 (0.8-1.1)	0.5 (0.3-0.8)	

Pasadena College of Chiropractic	1.1 (0.8-1.3)	1.3 (0.9-1.7)
Cleveland College, Kansas City, LA	7.9 (7.4-8.7)	7.9 (7.2-8.8)
University of Bridgeport College of Chiropractic	1.1 (0.9-1.4)	0.4 (0.3-0.7)
Canadian Memorial Chiropractic College	0.1 (0.05-0.2)	0.07 (0.02-0.2)
National U of Health Sc./ National School of Chiropractic	6.2 (5.7-6.8)	5.4 (4.8-6.2)
Southern California U of Health Sc./ LA Chiropractic College	14.1 (13.3-14.9)	14.6 (13.5-15.7)
Texas College	0.9 (0.7-1.2)	1.1 (0.8-1.5)
U. of Western States or Western States Chiro. College	6.9 (6.4-7.6)	5.7 (5.0-6.5)
Logan	0	0
Northwestern Health Sciences U	13.0 (12.3-13.9)	10.4 (9.5-11.4)
D'Youville College	0	0
New York College	1.1 (0.8-1.3)	5.4 (4.8-6.2)

Table 2. Patient characteristics for the year 2010 (aggregated at the care provider level)

<i>Number of chiropractor as of Dec 31th, 2010</i>	Contracted providers N=6946	With onsite imaging N=4094	χ^2, P value
Number of members across the network (active and inactive patients) since 1987	7,077,629	7,077,629	
Number of patients consulting contracted chiropractors	249,193	166,609	(330.5, 0.06)
Mean number of patient per chiropractor (SD)	35.87 (53.94)	40.7 (59.9)	
	N (%)	N (%)	
Number of patients per age groups			(176.1, 0.003)
18-35 years old	81 994 (32.9)	54920 (32.9)	
36-49 years old	90 372 (36.3)	60590 (36.4)	
50-65 years old	67 819 (27.2)	44722 (26.8)	
> 65 years old	8 968 (3.6)	6377 (3.8)	
Number of patients by gender			(235.8, 0.006)
Female	141 849 (56.9)	94 017 (56.4)	
Male	107 344 (43.1)	72 592 (43.6)	

SD = standard deviation

Table 3. Clinical and claims data and outcome measure across PN network for the year 2010

Variables (N=6946)	Sum	Mean per month	Mean (SD) per chiropractor	Variance	Range
Unique patients*	249 193	20 766	35.88 (53.93)	2908.04	756.0
New patient exams	91 542	7628.5	13.17 (19.30)	372.44	322.0
X-rays (count)					
Cervical spine	9 734		1.40 (3.89)	15.17	76.0
Thoracic spine	1 697		0.24 (1.15)	1.32	45.0
Lumbar spine	11 750		1.69 (4.48)	20.11	61.0
Full spine	188		0.03 (0.45)	0.20	20.0
Any spine x-rays (total)	23 369	1947.4	3.36 (8.63)	74.41	142.0
X-rays within 5 days of initial visit (count)					
Cervical spine	7 365		1.06 (3.12)	9.71	61.0
Thoracic spine	1 204		0.17 (0.86)	0.74	36.0
Lumbar spine	8 820		1.27 (3.54)	12.52	52.0
Full spine	122		0.02 (0.31)	0.10	20.0
Any spine x-rays (total)	17 511	1459.2	2.52 (6.80)	46.27	113.0
Main outcome measures			Annual Rate/1000 (SD)		
Immediate spine x-rays †					
cervical	-		82.3 (199.5)	0.040	3,0
thoracic	-		18.6 (97.3)	0.009	3,0
lumbar	-		100.5 (223.9)	0.050	3,0
Spine x-rays	-		204.2 (422.0)	0.178	4.0
Contracted providers with onsite imaging services (N=4094)					
Immediate spine x-rays			328.7 (497.0)	0.247	4.0

* Ensured individuals using chiropractic services for which there was at least one allowed paid service during the reporting period.

† Immediate spine x-rays = X-rays within 5 days of initial visit per new patient exams.

Table 4a. Regional variation in x-ray utilization rate by State for the year 2010

States with over 100 providers	Providers (N)	Immediate spine x-rays (mean, SD)
National	6946	0.20 (0.42)
Arizona	260	0.21 (0.37)
California	2392	0.16 (0.29)
Connecticut	120	0.20 (0.46)
Georgia	468	0.47 (0.56)
New Jersey	436	0.24 (0.48)
New York	643	0.15 (0.37)
Ohio	214	0.41 (0.70)
Oregon	340	0.10 (0.25)
Pennsylvania	1083	0.15 (0.37)
Utah	158	0.27 (0.41)
Virginia	247	0.36 (0.52)
Washington	164	0.22 (0.63)

Table 4b. Variation in x-ray utilization rate by Region for the year 2010 (N=6946)

US Region	Providers N (%)	Immediate spine x-rays (mean, SD)
Northeast	2343 (33.7)	0.167(0.404)
Midwest	251 (3.6)	0.370 (0.456)
South	906 (13.0)	0.410 (0.578)
West	3446 (49.6)	0.163 (0.333)

Table 5. Summary multivariate estimates Wald Chi-Square, *P*-value, and Incidence rate ratio (IRR) for immediate spine x-rays for the year 2010 among PN contracted chiropractors (N=6924), and two sensitivity analyses: Onsite imaging services (N=4085) and Spine x-rays per patients (N=6924)

† Coefficients are on an exponential scale ($\exp[\beta]$ = IRR (Incident Rate Ratios)); ‡ 95% CI = 95% Confidence Intervals.

Predictors	Immediate spine x-rays (main outcome measure)						Spine x-rays per patients		
	Contracted chiropractors (N=6924)				Onsite imaging (N=4085)		Contracted chiropractors (N=6924)		
	df	Wald Chi-Sq	<i>P</i>	IRR [†] (95% CI) [‡]	Wald Chi-Sq	<i>P</i>	Wald Chi-Sq	<i>P</i>	IRR [†] (95% CI) [‡]
Census region	3	100.22	<.0001	0.94 (0.89-0.98)	90.04	<.0001	121.6	<.0001	0.99 (0.92-0.99)
Chiropractic school	19	39.36	<.0001	1.71 (1.52-1.92)	16.41	<.0001	45.04	<.0001	1.74 (1.39-1.67)
Practice setting	2	6.82	0.05	0.96 (0.89-0.99)	3.43	0.1802	37	<.0001	0.86 (0.82-0.94)
Practice type	2	29.18	<.0001	1.41 (1.28-1.56)	19.49	<.0001	30.12	<.0001	1.37 (1.24-1.48)
Gender (provider)	1	26.04	<.0001	1.45 (1.25-1.69)		NS	32.75	<.0001	1.24 (1.09-1.40)
Office type	1	8.43	0.0037	0.84 (0.75-0.94)		NS	5.58	0.0182	0.88 (0.77-0.97)
Years in practice	3	14.47	0.0023	1.11 (1.04-1.19)		NS	5.45	0.14	1.05 (0.98-1.11)
Employment	1	8.33	0.0039	0.74 (0.64-0.86)		NS	4.56	0.03	0.79 (0.68-0.91)
Years enlisted with PN	3		NS		17.14	0.007		NS	

Table 6. Multivariate estimates of IRR and 95% CI adjusted for spine x-ray claims paid per patients AND Spine x-rays within 5 days of initial visit/new patient exams for the year 2010 among PN contracted chiropractors (N=6924)

		Contracted PN chiropractors (N=6924)		
Predictors		Immediate spine x-rays		
		IRR [†] (95% CI) [‡]	Wald Chi-Sq	P
Intercept		0.12 (0.08-0.17)	132.8	<.0001
Census Region	Northeast	1.09 (0.89-1.33)	0.68	0.411
	Midwest	2.21 (1.56-3.19)	18.89	<.0001
	South	1.89 (1.51-2.39)	29.31	<.0001
	<i>West</i> [§]			
Practice setting	Urban	1.23 (1.07-1.41)	8.37	0.003
	Suburban	1.21 (1.03-1.4)	5.46	0.019
	<i>Rural</i> [‡]			
Office type	Free standing clinic <i>Professional, medical building</i> [§]	1.16 (1.04-1.30)	6.72	0.009
Practice type	Solo	0.63 (0.49-0.8)	13.41	0.0002
	Group	0.88 (0.68-1.12)	1.06	0.303
	<i>Employee</i> [§]			
Chiropractic school	Bridgeport	0.55 (0.24-1.25)	2.07	0.150
	CMCC (Canada)	0.44 (0.09-3.24)	0.88	0.349
	Cleveland	1.67 (1.24-2.23)	11.78	0.0006
	Life	2.44 (1.78-3.33)	31.02	<.0001
	Life West	1.33 (0.97-1.83)	3.12	0.077
	Northwestern Health Sc. U	2.64 (1.51-4.89)	10.58	0.001
	NYCC	1.18 (0.84-1.64)	0.92	0.336
	National	1.22 (0.85-1.74)	1.18	0.276
	Palmer College (PCC)	2.29 (1.72-3.05)	32.75	<.0001
	Plamer Florida	1.95 (0.59-8.99)	0.96	0.326
	Palmer West	1.40 (1.05-1.88)	5.14	0.023
	Parker	2.08 (1.35-1.88)	10.81	0.001
	Pasadena	1.33 (0.80-2.31)	1.11	0.291
	Pennsylvania	0.52 (0.22-1.23)	2.28	0.131
	South California U Health Sc.	1.49 (1.15-1.94)	9.2	0.002
	Sherman	2.43 (1.54-3.89)	14.18	0.0002
	Texas	2.53 (1.34-5.05)	7.66	0.005
<i>University Western State</i> [§]				

Employment	Full time (≥ 25 hours/wk)	1.25 (1.07-1.45)	8.51	0.003
	Part time (< 25 hours/wk) [§]			
Years in practice	< 5 years	0.70 (0.55-0.89)	8.31	0.003
	6-10 years	0.89 (0.76-1.06)	1.63	0.201
	11-20 years	0.83 (0.70-0.91)	10.13	0.001
	> 20 years [§]			
Gender (Provider)	Female	0.67 (0.58-0.78)	27.34	<.0001
	Male [§]			
Dispersion (Alpha)		3.75 (3.53-3.98)	t =33.12	<0.001

§ Reference; † Coefficients are on an exponential scale ($\exp[\beta] = \text{IRR}$ (Incident Rate Ratios)); ‡ 95% CI = 95% Confidence Intervals.

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CHAPTER THREE

IMPACT OF GUIDELINE DISSEMINATION STRATEGIES

"I have been impressed with the urgency of doing.

Leonardo da Vinci (1452-1519)

Impact of guideline dissemination strategies among chiropractors enlisted in a Provider Network in the United States: Interrupted time series with segmented regression analysis²

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Abstract

Background: Overuse and misuse of imaging for spine disorders persists among chiropractors. Distribution of educational materials results in small to modest improvements in appropriate care such as ordering spine x-rays, but little is known about its impact among North American chiropractors.

Objectives: To evaluate the impact of web-based dissemination of a diagnostic imaging guideline in reducing chiropractors' use of spine x-rays.

Research Design: Interrupted time series to evaluate the effect of guidelines dissemination on spine x-ray claims by chiropractors in a large network of complementary care providers across the US.

Methods: The intervention was delivered in April 2008. Administrative claims data were extracted between January 2006 and December 2010. Segmented regression analysis with autoregressive error was used to estimate the impact of guideline recommendations on the rate of spine x-rays. Sensitivity analysis considered the effect of two additional quality improvement strategies.

Results: Time series analysis revealed a significant change in the level of spine x-rays ordering soon after introduction of the guidelines (-0.01 ; 95% CI= $-0.01, -0.002$; $p=0.01$), but no change in trend of the regression lines. The monthly mean rate of spine x-rays within 5 days of initial visit per new patient exams decreased by 10 per 1000, a 5.26% relative decrease after guideline dissemination. Controlling for two quality improvement strategies did not change the results.

Conclusions: Web-based guideline dissemination was associated with a stepwise reduction in spine x-ray claims. Sensitivity analysis suggests our results are robust. This passive strategy is likely cost effective in a chiropractic network setting.

Keywords. Chiropractors, health care, primary care, quality assurance, test ordering.

Introduction

Overuse, and misuse of imaging for spine disorders has been reported in the medical [1, 2] and chiropractic literature [3, 4]. Spine x-rays are of little clinical use in the absence of specific clinical indicators (red flags) [5, 6]. Potential harms from inappropriate use of spine x-rays include unnecessary patient exposure to ionizing radiation [7-9], and inefficient and potentially inappropriate further investigations including MRI and CT scan and subsequent treatment [10-12]. Although evidence-based diagnostic imaging guidelines are available, chiropractors remain divided on whether current recommendations for spine imaging apply to them [3, 13, 14].

Clinical practice guidelines (CPGs) are particularly useful where there are concerns about the appropriateness of care. The Diagnostic Imaging Guidelines for Adult Spine Disorders (DIGASD) were developed to assist clinical decision-making and promote more selective use of imaging studies by chiropractors and other primary health care professionals [15]. Although these guidelines were released in 2008, recent systematic reviews [5], best evidence synthesis [6], and national guidelines [16, 17] still support the key recommendations for spine imaging of uncomplicated neck and back pain. In a review on the impact of guideline implementation and dissemination strategies in allied health professions, only three of the fourteen included studies focused on physiotherapists and there were none on chiropractors [18].

Distribution of printed educational material (PEM) such as posting of guidelines on the web are widely used passive dissemination strategies to improve knowledge, awareness, attitudes, skills, professional practice and patient outcomes. Recent high quality reviews suggested distribution of PEM was effective for improving physician ordering x-rays for low back pain [19, 20] and other musculoskeletal conditions [19, 20]. However, little is known about the impact of

dissemination of diagnostic imaging guidelines for spine x-ray ordering behaviour among chiropractors in the United States setting [18]. We undertook an Interrupted time series (ITS) to assess the impact of web based dissemination of a spine imaging guideline on spine x-ray claim rates among chiropractors enlisted with the American Specialty Network (ASH), a large chiropractic Provider Network (PN) in the United States.

Methods

Design

A retrospective, quasi-experimental design using segmented regression analysis of interrupted time series (ITS) data was performed to assess the significance of changes in level and slope of the regression lines before and after the introduction of a spine imaging guideline [21, 22]. ITS design allows for the statistical investigation of potential biases in the estimate of effect of the intervention. These potential biases include: secular trend, seasonal effects, duration of the intervention, random fluctuations, and autocorrelation [23].

Setting

The PN provides complementary health care networks for health plans across the US, and includes over 15,000 chiropractors from 50 states [24].

Participants

Contracted providers who received payment for at least one claim submitted between 2006 and 2010 for consecutive adult patients consulting for complaints of spine disorders were identified from the PN administrative databases.

Interventions

The primary intervention was the introduction of the Diagnostic Imaging Guidelines [15]. These open access guidelines were first published in the Journal of Manipulative and Physiological Therapeutics in January 2008 [15]. In March 2008, the guidelines were posted on the National Guideline Clearinghouse™ [25] and the PN updated their web-based diagnostic imaging guidelines accordingly in May 2008. Consequently, the intervention is considered as occurring on April 01, 2008. Table 1 provides a description of the delivery of the intervention with corresponding periods.

Associated quality improvement initiatives

The PN clinical staff retrospectively identified quality improvement (QI) initiatives to improve appropriate use of spine x-rays. The PN assigned chiropractors to one of six levels (provider tier system) based on service utilization including x-ray ordering practice, and quality data. Each level defines the point at which medical necessity review is applied. Two QI strategies were targeted at high x-ray users during the study period: (1) a policy change introduced across the network in December 2006, and (2) an educational intervention delivered in September 2007 in the state of Georgia (Table 1).

Data sources

Data were extracted between January 1st, 2006 and December 31st, 2010 from the ASH administrative claims database. The database contains claims data for billed services submitted by the PN contracted practitioners. Data was extracted for consecutive patients over the age of 18 who were treated for complaints of neck, back or low back pain. Duplicate claims submissions and Medicare contracts were excluded. Diagnostic and procedure codes used are

classified under the *International Classification of Disease, Ninth Revision* (ICD-9) [26] and the *Current Procedural Terminology (CPT), Fourth Edition* [27].

The following complete datasets were extracted each month at the care provider level for patients consulting for spinal complaints during the study period: (a) number of 'unique' patients defined as insured individuals using chiropractic services for which there was at least one allowed paid service during the reporting period); (b) number of 'new patient exams' claims for complaints of spinal disorders; and (c) spine x-ray ordering claims data (cervical, thoracic, lumbar and full spine x-rays) were extracted for the entire study period and if ordered within five days of a billed initial patient visit. Each service for a radiographic exam as identified by the applicable CPT code was counted as an x-ray study. PN officials routinely assess billing patterns and audit chiropractors to ensure billing accuracy. In addition, reliability of data extraction process were assessed by two study investigators on two occasions (February and June 2011) at the PN headquarters in San Diego by comparing randomly selected cases with the original dataset.

Outcome Measures

The physiological measure was a change in the *mean number of spine x-ray claims ordered within five days of initial patient visit per 1000 new patient exams per month* immediately after the introduction of the guidelines, and any differences between pre-intervention and post-intervention trends. A third outcome of ITS analysis is the estimation of monthly average intervention effect after the intervention [21, 22].

Ethics

A data use agreement was signed by involved parties and ethics approval was granted by the Ottawa Health Research Ethics Boards.

Data analysis and management

Encrypted data were downloaded into an Excel file, transposed into a 60-month observation period, and converted using SAS statistical software (version 9.2) in July 2011. A two-sided $p < 0.05$ was considered statistically significant and analyses were performed using SAS enterprise guide (version 4.2). We estimated changes in level and trend for the dissemination of the guidelines, and conducted sensitivity analyses on the PN QI strategies (Additional file 1). The Durbin-Watson (dw) statistic was utilized to test for autocorrelation. The dw statistic detected no evidence of autocorrelation (dw=1.95, $p=0.99$). Nonetheless, since time series data are typically auto-correlated, we undertook a conservative approach and utilized regression analysis with autoregressive errors.

Primary analysis

Estimating changes in level and trend for the dissemination of the guidelines

To determine the expected mean number of the dependent variable following exposure to the intervention, three variables were entered into the time series model: a) a time variable; b) an indicator variable to differentiate between pre and post-guideline publication period; and c) a post-intervention term. The autoregressive error structure (v_t) represents the random variability not explained by the model. We specified the following linear regression model:

$$Y_t = \beta_0 + (\beta_1 * \text{Time}_t) + (\beta_2 * \text{Intervention}_t) + (\beta_3 * \text{Time}_t \text{ after Intervention}_t) + v_t \text{ (error term)} \quad (1)$$

Intervention effects

Three outcomes in the ITS analysis are: first, change in level immediately after the intervention; second, difference between pre-intervention and post-intervention slopes; and third, the estimation of monthly average intervention effect after the intervention [22, 28, 29]. To estimate the intervention effect across PN providers, the expected results from regression equation 1 at month 60, which is 32 months after the CPGs were disseminated, is expressed as [22, 29]:

$$\hat{Y}_{60(\text{with CPGs})} = \hat{\beta}_0 + \hat{\beta}_1 \times 60 + \hat{\beta}_2 \times 1 + \hat{\beta}_3 \times 32 \quad (2)$$

The following expresses regression equation 1 at month 60 had the CPGs not been disseminated (i.e., without any post-intervention effect in the model):

$$\hat{Y}_{60(\text{without CPGs})} = \hat{\beta}_0 + \hat{\beta}_1 \times 60 \quad (3)$$

Intervention effects may be expressed as the absolute intervention effect:

$\hat{Y}_{60(\text{with CPGs})} - \hat{Y}_{60(\text{without CPGs})} = \hat{\beta}_2 + \hat{\beta}_3 \times 32$, or as the relative change in outcome associated with the CPGs, expressed as percentage increase or decrease:

$$\frac{\hat{Y}_{60(\text{with CPGs})} - \hat{Y}_{60(\text{without CPGs})}}{\hat{Y}_{60(\text{without CPGs})}} \times 100.$$

Sensitivity analysis

Estimating changes in level and trend for the PN quality improvement strategies

To control for changes in level and trend of the series that are caused by reasons other than the release of the Diagnostic Imaging Guidelines, we conducted separate time series by adding the PN QI strategies as a change point in the segmented regression analysis of ITS, along with the primary intervention disseminated at month 29. The model with 2 points change was [22]:

$$Y_t = \beta_0 + (\beta_1 * \text{Time}_t) + (\beta_2 * \text{Intervention}_t) + (\beta_3 * \text{Time}_t \text{ after Intervention}_t) + (\beta_4 * \text{QI strategy}_t) + (\beta_5 * \text{Time}_t \text{ after QI strategy}_t) + v_t \text{ (error term)} \quad (4)$$

We first conducted a time series analysis adding the policy change implemented across the PN at month 12 (figure 1). We performed a separate analysis using data for the state of Georgia only, adding both QI strategies, the policy change at month 12 and an educational intervention at month 21 (figure 2).

Results

Over the 5 year period, more than 605,500 new patient exam claims were made for 4,554,362 patients. Spine x-ray utilization claims decreased steadily over the five year period, with a mean of 248.2 (95% CI: 247.9-248.5) spine x-ray claims per 1000 new patient exams per month before, and 203.3 per 1000 (95% CI: 202.9-203.6) after guidelines dissemination (Table 2).

Primary analysis: Guidelines dissemination

Visual inspection suggests a downward trend in use of spine x-ray claims throughout the study period, with an abrupt level change occurring soon after the intervention at around month 29 (figure 1).

The coefficients, associated 95% confidence intervals (CIs), and significance level for each variable are presented in Table 3. At the beginning of the observation period, chiropractors claimed for average 265 out of 1000 *spine x-rays within 5 days of initial visit per new patient exams per month*. A small but significant level change in the mean number of spine x-ray claims per new patient exams per month (about 10 per 1000) was observed immediately after the guidelines were released (-0.0104, 95% Confidence Interval (CI): -0.0182,-0.0026, $p=0.0114$). There was a significant overall decrease in the rate of spine x-rays claims over the study period ($p<.0001$), but the rate of decrease did not appear to change after the intervention (p -value = 0.8536). After stepwise elimination of non-significant terms, the most parsimonious model

contained only the intercept, the baseline trend, and the level change in the mean number of spine x-rays claims after guidelines release (-0.0103, 95% CI=-0.0180,-0.0026; $p=0,0109$).

Using results in Table 3, we estimated that at 60 months, PN chiropractors claimed for 186 spine x-rays per 1000 new patient exams per month. Had the CPGs not been introduced, the mean monthly rate of spine x-ray claims per new patient exams would have been 196 per 1000. Thus, the average rate of spine x-ray claims per new patient exams per month decreased by 10 spine x-rays per 1000 (the absolute intervention effect), or 5.26% after the CPGs were disseminated, compared with what it would have been without the CPGs (a relative percentage decrease).

Sensitivity analysis: Provider Network quality improvement (QI) strategies

A significant level change remained after controlling for PN quality improvement strategies across the network (figure 1) and in Georgia State (figure 2).

Discussion

Segmented regression analysis of a 5 year interrupted time series showed that web-based dissemination of a diagnostic imaging guideline among a large group of chiropractors in a PN setting was associated with a significant change in level (step) but not trend in x-ray claims. The change in level remained significant after controlling for previous PN quality improvement strategies targeting high x-ray users, suggesting our findings are robust. We also observed an underlying secular reduction in x-ray claims over the study period. Such downward trend has been observed over the past decades among chiropractors in North America [3, 30-32] and overseas [33, 34].

To our knowledge, this is the first study to document, with a robust methodology, a decrease in spine x-ray claims after web-based dissemination of printed educational material (PEM) among chiropractors enlisted in a PN. Our results concur with the recent updated Cochrane review that suggests PEM are generally effective strategies for improving process of care among physicians and result in small to modest improvements [35]. Giguère's review included 45 studies comprising 14 randomised trials (RCTs) and 31 interrupted time series (ITS) studies [35]. For RCTs, the median absolute improvement in continuous professional practice outcomes was 0.13 SMD (range from -0.16 to +0.36) when PEMs were compared to no intervention. Results for ITS studies were consistent across studies and support above conclusions (standardized median change in level of 1.69, range from -6.96 to +14.26). Only three studies included non physicians (nurses, pharmacists, or psychologists), and mode of delivery of PEMs rarely consisted of web-based dissemination. A recent randomized trial in the UK showed that posted PEM can shift chiropractors', osteopaths' and physiotherapists' beliefs and self-reported behaviour toward treatments more in line with guideline recommendations [36]. However, the trial did not include recommendations for lumbar x-rays and had a short follow-up.

Implications for research

While the evidence-based movement is now prominent in orthodox medicine, this paradigm shift has been a much slower process in chiropractic [37]. Whilst there is a substantial evidence base focusing on changing physician practice (e.g., improving prescribing and medicines use) [38], the applicability of this research to chiropractic is uncertain given the differences in chiropractors' training and practice patterns [39, 40]. To date, there has been little knowledge translation (KT) research in chiropractic. We are aware of only one (ongoing) cluster trial evaluating Australian chiropractors' compliance with a CPG to reduce lumbar x-rays for acute

lower back pain [41]. Further KT research in chiropractic is needed to identify optimal strategies to improve practice in this professional group.

Implications for practice and policy makers

Chiropractic care and complementary and alternative medicine (CAM) are increasingly being used [42] and integrated into group practice organizations and mainstream health care [43] with significant potential economic benefits [44]. Further integration of CAM however should be founded on sound evidence-based principles of quality health care delivery [43].

Policy makers within a PN setting should consider web-based dissemination of evidence-based guidelines as an initial step to reduce knowledge-practice gap. Greater effect may be achieved through active dissemination strategies [45].

Limitations

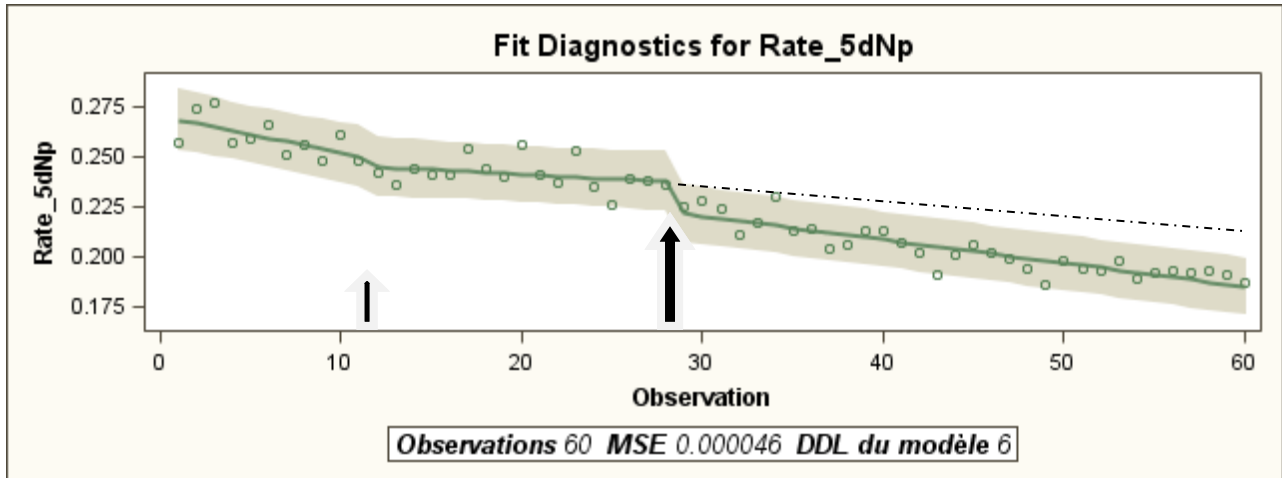
Although our study had a number of strengths, including use of a robust design, a large sample size, inclusion of consecutive patient encounters with chiropractors enlisted in one of the largest PN across the United States, and a long study period (this study had 60 observations and no autocorrelation was found), some limitations must be considered. First, determinants of health care utilisation including patient health status and extent of health-care insurance coverage were not available for analysis. Second, appropriateness of x-ray ordering cannot be addressed as the available administrative data lacked detailed clinical information such as presence of red flags, specific diagnosis, and disease severity. Third, providers could have ordered x-rays without submitting claims for them. Fourth, it is unclear if other tests were being substituted for undergoing x-rays such as MRIs.

The biggest threat to time series analysis is an event occurring at the same time as the intervention producing a similar effect (i.e., history) [21, 46]. While a number of national guidelines on back pain were released or updated during the study period [16, 17], CPGs made available in 2008 were in Finnish [47] or housed under the National Health Service in the UK [48], a website unlikely to be frequently visited by US chiropractors. One other notable event was the online release of a chiropractic imaging guideline at the end of 2007 [14]. History is not plausible however because this chiropractic guideline promoted the routine use of spine x-rays, a behavior in the opposite direction of the Diagnostic Imaging Guideline which consistently recommends not using x-rays in the absence of red flags. A second common threat to time series analysis is a change in the composition of the study population. This seems unlikely because: (1) there was no atypical change in the mean number of providers per month in the adjacent months before and after the intervention; (2) there are no compelling reasons why patient characteristics, severity of presenting complaints, and co-morbidity would change when CPGs were disseminated; and (3) it seems improbable that such a large number of providers would stop using their x-ray equipment in response to the dissemination of the guidelines. Two other common threats to time series analysis are seasonality and testing effect. No important seasonality (cyclical variation) was expected, and inclusion of 60 data points likely captured potential seasonal variations in the pre- and post-intervention periods. Lastly, testing effect is unlikely as there was no change in the way claims were recorded during the study period.

Conclusions

Web-based dissemination of diagnostic imaging guidelines was associated with a reduction in the x-ray claims by chiropractors enlisted with a large network of providers in the US. Passive guidelines dissemination appeared to be a simple, cost-effective strategy in this setting to improve x-ray ordering rates. Further research is needed to find more efficient guideline dissemination strategies. Interventions aiming to further reduce x-ray utilization should identify barriers to change and target high users in identified geographical areas, and aim to clarify the effect of a provider tier system on x-ray ordering practice in a managed system.

Figure 1. Monthly use of spine x-ray per new patient exams across the PN before and after guidelines dissemination, controlling for the Provider Network policy change.

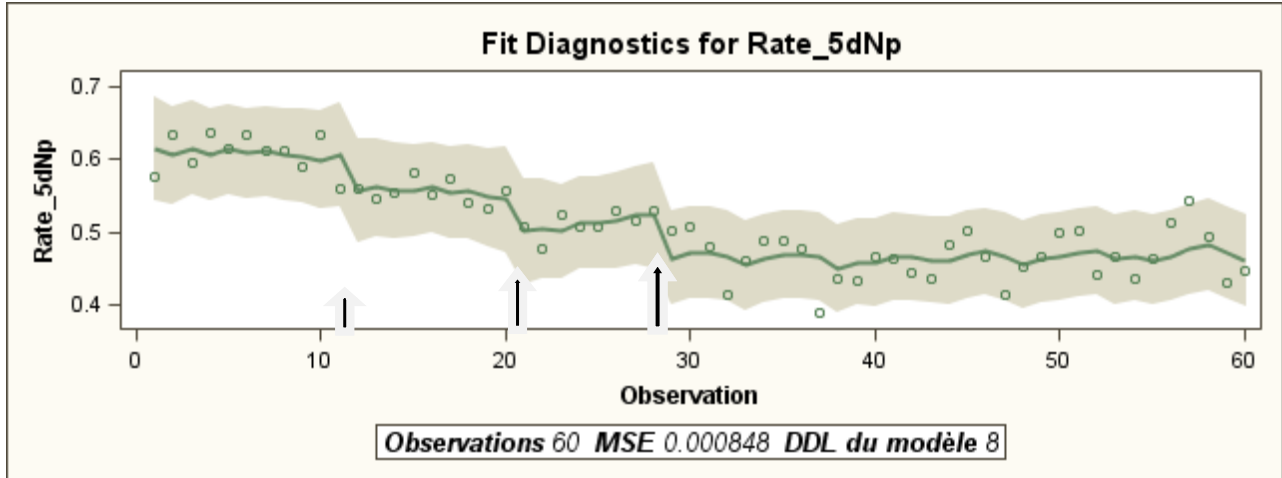


Rate_5dNP: X-rays ordered within 5 days of initial patient visit per new patient exam

- Short arrow: Provider Network policy change (QI strategy)
- Long arrow: Guidelines dissemination (primary intervention)

We specified a pre-intervention slope variable and two level and slope change variables, one each for Provider Network policy change at month 12 and the guidelines dissemination at month 29.

Figure 2. Monthly use of spine x-ray per new patient exams in Georgia State before and after guidelines dissemination controlling for two quality improvement strategies.



Rate_5dNP: X-rays ordered within 5 days of initial patient visit per new patient exam

- Short arrow: Provider Network policy change (QI strategy)
- Medium size arrow: Provider Network educational intervention (QI strategy)
- Long arrow: Guidelines dissemination (primary intervention)

We specified a pre-intervention slope variable and two level and slope change variables, one each for Provider Network policy change at month 12 and Provider Network educational interventional month 21, and the guidelines dissemination at month 29.

Table 1. Description of the delivery of the primary intervention (guidelines dissemination) and the Provider Network (PN) quality improvement strategies, and corresponding periods.

Event	Description	Period
Pre-intervention		<p>January 01, 2006 - March 31, 2008 (28 months) <i>Rationale:</i> PN clinical service managers verification of medical necessity for x-ray services submitted was based on the existing PN guidelines available on their website before March 31, 2008.</p>
Primary intervention		
<ul style="list-style-type: none"> • Web-based guideline dissemination 	<p>The primary intervention was the introduction of the Diagnostic Imaging Guidelines (DIGASD)*. The full guidelines were first published in a peer review journal in January 2008, are open access and available through Pubmed. In March 2008, the guidelines were posted on the National Guideline Clearinghouse™ (NGC) and the PN updated their web-based diagnostic imaging guidelines accordingly.</p>	<p>April 01, 2008 (Month 29) <i>Rationale:</i> Given a few months delay is expected between guideline publication and guideline awareness, and web posting (NGC and PN) occurred in March 2008, the intervention is considered to have occurred on April 01, 2008.</p>
Post-intervention		<p>April 1, 2008 - December 31, 2010 (32 months) <i>Rationale:</i> PN clinical service managers verification of medical necessity for x-ray services submitted was based on the PN updated guidelines available on their website after April 1, 2008. Accordingly, the primary intervention may consider as sustained until the end of the study period.</p>
Provider Network quality improvement initiatives		

<ul style="list-style-type: none"> PN policy change focusing on new and existing providers across its network 	<p>New providers: Tier** 2 credentialing process was implemented by the PN in March 2006, enabling the PN to accept applicants with high x-ray utilization while maintaining quality oversight. These chiropractors received an educational packet (notification letter, description of tier 2 requirements, and PN x-ray guidelines), followed by an educational phone call and three educational letters over their first 12 months.</p> <p>Existing providers: In December 2006, the PN implemented a program focused on contracted chiropractors with high x-ray rates. Upon annual review, providers exceeding the revised parameters (spine x-ray rates > 60% and/or full spine x-ray rates >5%) were assigned to tier 2. Under tier 2, all x-ray services required medical necessity review prior to submitting x-ray claims for reimbursement.</p>	<p>December, 2006 (Month 12) <i>Rationale:</i> Considering that PN tier 2 credentialing and remedial educational processes for new providers occurred over a 12 month period, and the PN revised x-ray parameters and tier level change for existing providers started in December, PN tier 2 policy change, a multifaceted intervention according to the Effective Practice and Organizational Care (EPOC) taxonomy [1], is reputed to have occurred in December 2006.</p>
<ul style="list-style-type: none"> Educational intervention in Georgia state 	<p>Education letter sent to all Georgia providers whose x-ray utilization rate was equal or greater than 60%</p> <p>Phone outreach educational calls to providers seeing a minimum of 10 patients and x-ray utilization was greater than 60% (not already in tier 2)</p>	<p>September 2007 (Month 21)</p>

* DIGASD: Diagnostic Imaging Guideline for Adult Spine Disorders

** Provider tier: As part of a quality improvement (QI) initiative implemented in 2005, PN assigned chiropractors to one of six levels (provider tier) based on service utilization including x-ray ordering practice, and quality data. Each level defines the number of patient visits and services permitted before verification of medical necessity is required. Provider tier ranges from having to submit documentation for medical necessity verification for all services after the first visit (tier 1) to no medical necessity verification (tier 6). Providers can move up or down in tier level on an annual basis based on compliance with both quantitative and qualitative criteria

Table 2. Mean monthly number of new patient exams, spine x-rays within 5 days of initial exam, and rate of spine x-rays within 5 days per 1000 new patient exams before and after the intervention among Provider Network chiropractors in the US.

Across ASH Networks	Pre-CPG (first 28 months: Jan 2006-March 2008)	Post-CPG (last 32 months: April 2008-Dec 2010)
New patient exams Mean per month (SD)	10,708.6 (1040.7)	9552.8 (817.1)
Spine x-rays within 5 days of initial exam Mean per month (CI)	2662.1 (2677.0 - 2787.6)	1945.2 (1945.16 - 2029.4)
Mean monthly rate of spine x-rays within 5 days per 1000 new patient exams Mean per month (CI)	248.22 (247.93 - 248.51)	203.29 (202.99 - 203.59)

* New patient exams: Patient between age 18 and 65 years with chief complaints of neck, thoracic or low back pain during the study period 2006-2010; SD: standard deviation; 95%CI: Confidence intervals.

Table 3. Parameter estimates, confidence intervals and *P*-values from the full and most parsimonious segmented regression models predicting mean monthly numbers of spine x-rays within 5 days of initial visit per new patient exams across the Provider Network over time.

Guidelines dissemination	Coefficient	95% CI†	<i>P</i>-value
a. Full segmented regression model			
Intercept <i>B</i> ₀	0.2645	(0.2586, 0.2701)	<.0001
Baseline trend <i>B</i> ₁	-0.0011	(-0.0015, -0.0008)	<.0001
Level change after guidelines release <i>B</i> ₂	-0.0104	(-0.0182, -0.0026)	0.0114
Trend change after guidelines release <i>B</i> ₃	-0.00004	(-0.0005, 0.0004)	0.8536
b. Most parsimonious segmented regression model			
Intercept <i>B</i> ₀	0.2649	(0.2606, 0.2692)	<.0001
Baseline trend <i>B</i> ₁	-0.0012	(-0.0014, -0.0009)	<.0001
<i>Level change after guidelines release B</i>₂	-0.0103	(-0.0179, -0.0026)	0.0109

† 95% CI = 95% Confidence Intervals

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RESEARCH

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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

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Abstract

Background: The Theoretical Domains Framework (TDF) was developed to investigate determinants of specific clinical behaviors and inform the design of interventions to change professional behavior. This framework was used to explore the beliefs of chiropractors in an American Provider Network and two Canadian provinces about their adherence to evidence-based recommendations for spine radiography for uncomplicated back pain. The primary objective of the study was to identify chiropractors' beliefs about managing uncomplicated back pain without x-rays and to explore barriers and facilitators to implementing evidence-based recommendations on lumbar spine x-rays. A secondary objective was to compare chiropractors in the United States and Canada on their beliefs regarding the use of spine x-rays.

Methods: Six focus groups exploring beliefs about managing back pain without x-rays were conducted with a purposive sample. The interview guide was based upon the TDF. Focus groups were digitally recorded, transcribed verbatim, and analyzed by two independent assessors using thematic content analysis based on the TDF.

Results: Five domains were identified as likely relevant. Key beliefs within these domains included the following: conflicting comments about the potential consequences of not ordering x-rays (risk of missing a pathology, avoiding adverse treatment effects, risks of litigation, determining the treatment plan, and using x-ray-driven techniques contrasted with perceived benefits of minimizing patient radiation exposure and reducing costs; beliefs about consequences); beliefs regarding professional autonomy, professional credibility, lack of standardization, and agreement with guidelines widely varied (social/professional role & identity); the influence of formal training, colleagues, and patients also appeared to be important factors (social influences); conflicting comments regarding levels of confidence and comfort in managing patients without x-rays (belief about capabilities); and guideline awareness and agreements (knowledge).

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Conclusions: Chiropractors' use of diagnostic imaging appears to be influenced by a number of factors. Five key domains may be important considering the presence of conflicting beliefs, evidence of strong beliefs likely to impact the behavior of interest, and high frequency of beliefs. The results will inform the development of a theory-based survey to help identify potential targets for behavioral-change strategies.

Keywords: Theoretical domains framework, Focus groups, Content analysis, Social/professional role and identity, Social influence, Chiropractors, Radiography, X-ray guidelines, Back pain

Background

Diagnostic imaging is commonly used in the management of musculoskeletal problems to improve precision in diagnosis prior to treatment. However, overuse and misuse of imaging services for spine disorders has been reported in the medical [1-4] and chiropractic literature [5-10]. Current evidence suggests that routine radiography is unnecessary during the initial evaluation of uncomplicated back pain unless specific clinical indicators (red flags) are present [4]. A more conservative approach to the diagnostic evaluation is therefore advisable, both in terms of health risk and resource allocation [11,12].

Clinical practice guidelines (CPGs) aim to describe appropriate care based on the best-available scientific evidence and broad consensus, while promoting efficient use of resources [13]. Although evidence-based diagnostic imaging guidelines for spinal disorders are available [14-16], chiropractors are divided on whether these guidelines apply to them [5,17-20]. Wide variations in lumbar spine x-ray ordering have been reported in North America, ranging from 12% to 26% of patients presenting with low back pain [18,21-23] to well over 55% [5,6,24-27]. The Diagnostic Imaging Guidelines for Adult Spine Disorders (DIGASD) were recently developed to assist clinical decision making and encourage more selective use of imaging studies by chiropractors and other primary healthcare professionals [28].

While CPGs can encourage providers to practice evidence-based care [29,30], passive dissemination of guidelines is unlikely by itself to lead to optimal practice [31,32]. By themselves, CPGs cannot overcome the multitude of barriers to clinician adherence [33]. Several competing beliefs can prevent practitioners from using best evidence. Identifying determinants of specific clinical behavior likely to influence the implementation of practice guidelines is a recommended initial step to tailor interventions to improve patient care [34-37].

Studies exploring factors influencing use of lumbar x-rays for low-back pain patients have generally focused on physicians, and both clinical and nonclinical factors have been found to be associated with test ordering [38-46]. Fewer studies have examined factors that affect chiropractors' decisions to order x-rays [6,19,20,39,47] (see Additional file 1). We are aware of no studies

comparing chiropractors' beliefs about the use of x-rays in the American and Canadian settings. Furthermore, very few studies have used a theory-based approach to identify barriers and facilitators to behavior change among chiropractors [48]. Theories can provide a framework for interpreting and predicting behavior, help tailor interventions to improve the likelihood of successful change, and can help evaluate potential causal mechanisms [49-54].

Psychological theories explaining behavior and behavior change are numerous and share overlapping constructs [55-57]. To maximize the accessibility and usefulness of psychological theories to researchers involved in evidence-based practice implementation, Michie and colleagues mapped 128 constructs from 33 theories and identified 12 discrete domains [58]. The Theoretical Domains Framework (TDF) covers a broad spectrum of individual and organizational theories, thereby limiting the risk of omitting important areas when exploring factors that may impact decision making regarding the use of evidence-based care in clinical practice. We used the TDF to explore chiropractors' beliefs about management of low-back pain without imaging in two countries. This article is one in a series of articles documenting the development and use of the TDF to advance the science of implementation research. The series' introductory article [59] provides an overview of the articles contained in the TDF Series.

Methods

Design

We conducted six focus groups based on the TDF with chiropractors in America and Canada. The interactive nature of focus groups can promote synergy among participants and allows exploration of collective memories, positions, ideology, practices, and desires among specific groups of people [60]. Focus groups are particularly useful when group norms and cultural values of particular groups are of interest and to explore the degree of consensus on a given topic [61,62].

Context

Participants were identified from the American Specialty Health (ASH) Network service lists from two states

(California and Georgia) that had differing x-ray-ordering rates and professional associations in Ontario and Quebec, Canada. The ASH Network provides complimentary healthcare, including chiropractic services, across the United States [27]. The ASH Network assigns chiropractors to one of six levels based on quality performance indicators, such as inappropriate or high x-ray-ordering practice. Each level defines the number of patient visits and services permitted before verification of medical necessity is required. Providers can move up or down in tier level following retrospective annual reviews based on guidelines compliance.

Participants

Participants were licensed chiropractors in full-time practice and/or had prolonged experience as chiropractic educators. A purposive sample was drawn from the provider organizations to seek respondents across a spectrum (geographical area, chiropractic school attended, x-ray-ordering practice, years in practice, and expertise) to ensure that all viewpoints would be adequately represented.

Materials

The specified target behavior was managing uncomplicated back pain without x-rays. An interview topic guide based on the TDF was developed [58] (see Additional file 2). Questions were informed by previously published work on the topic [43,54,63-67]. Probes were used where necessary for further clarification [68]. Face and content validity of the interview guide were initially assessed by experts in knowledge translation (JMG, JJF) and expert chiropractors, thereby ensuring that questions adequately covered each theoretical domain and were relevant to the clinicians. The number of questions ranged between two and seven for each of the 12 domains, for a total of 43 questions.

Procedure

A total of 154 practitioners were invited to take part in focus groups consisting of four to six practitioners between February and July 2010. A customized letter invited care providers to participate. We followed up with the first 25 respondents via email or telephone. Those who agreed to participate were asked to review relevant recommendations of the DIGASD one to two weeks prior to the interview. The focus groups lasted between 60 and 90 minutes. They were digitally recorded, and field notes were taken by a nonparticipant observer during three of the six groups. It was not possible to arrange for a note taker to attend the other locations; however, the interviewer (AEB) made notes after each focus group. Data were transcribed verbatim and anonymized prior to analysis.

Analysis

Transcripts were coded independently by two investigators (AEB and AMP) and disagreements formally resolved at each step. One author (JJF), a health psychologist, provided a critique of the analysis and interrogated the coding to ensure a robust and defensible coding of the data into beliefs and relevant domains.

We initially coded each utterance into relevant theoretical domains from the TDF onto an Excel spreadsheet. Utterances were counted twice if a participant gave a response similar to that of another participant. Coding was guided by our understanding of the constructs within a domain. Utterances unlikely to be relevant to lumbar x-ray-ordering practice were placed into a separate file for further analysis.

Then we linked utterance responses with specific beliefs. A specific belief is a statement that provides detail about the role of the domain in influencing the behavior [66]. These statements intended to convey a meaning that was common to multiple utterances. AEB generated specific beliefs from utterances that captured the core thought and continued this process for every utterance. Beliefs, coded as being similar or identical statements, were then grouped together according to their likelihood to either increase (i.e., perceived barriers to guideline adherence), decrease (i.e., perceived to facilitate or help guideline adherence), or have no influence on x-ray-ordering behavior. Two to three emerging, overarching themes were proposed for each domain. Specific beliefs and overarching themes were reviewed for agreement by AMP and JJF.

Finally, we identified relevant domains based upon the following criteria: (1) presence of conflicting beliefs, (2) evidence of strong beliefs that were perceived to impact the behavior, and (3) high frequency of specific beliefs. All three criteria were weighed equally to judge relevance of the domains as they relate to influencing target behavior [66,69].

To assess whether or not we had achieved data saturation [70], we conducted concurrent data analysis and coding; themes were recurring after the third focus group, and no new themes emerged after the fifth focus group.

Comparison of US and Canadian participants

American and Canadian participants were compared on (1) distribution of utterances within each domain, (2) identification of specific beliefs within domains, and (3) identification of relevant domains likely to influence lumbar x-ray-ordering behavior.

Ethics

A signed collaborative agreement by the ASH Network was submitted to the Ottawa Hospital Research Ethics Board, Canada, who granted ethic approval.

Results

Characteristics of participants

Six focus group interviews were conducted (21 chiropractors), including two in California (n = 8), two in Georgia (n = 6), one in Ontario (n = 3), and one in Quebec (n = 4). The average age of participants was 44.2 years (SD ± 9.2), 28% (5/21) were females, and the average number of years in practice was 13.8 years (SD ± 7.9). Age, gender, and years in practice of our sample are representative of national averages in North America [71,72]. Sixteen participants were in full-time practice, five were academics or lecturers, and ASH provider tier level ranged from 3 to 6. Nearly 40% of interviewees reported ordering x-rays on over half of patients presenting with nonspecific back pain (nature of the behaviors; Table 1).

Key themes identified within relevant domains

Coding by two independent assessors identified 1,183 utterances representing 88 specific beliefs and 23 themes. Interrater reliability was not assessed as 100% consensus was achieved at each step. Key themes emerging from the focus groups with chiropractors were

categorized within five theoretical domains: beliefs about consequences, social/professional role and identity, social influences, beliefs about capabilities, and knowledge (Table 1).

Twenty-nine percent of utterances focused on the domain of beliefs about consequences, two-thirds of which related to factors increasing the likelihood of ordering x-rays. Distribution of utterances perceived to increase spine x-ray ordering (barriers) among participants was also greater for the domains of social/professional role and identity and social influences and marginally higher for environmental context and resources. Conversely, distribution of utterances likely to decrease x-ray ordering (facilitators) was higher for the domains of beliefs about capabilities, knowledge, and, to a lesser extent, memory, attention, and decision process and behavioral regulation. Domains of skills and emotion were very rarely mentioned.

We report the findings of key domains together with illustrative quotes grouped as “beliefs likely to increase x-ray ordering” and “beliefs likely to decrease x-ray ordering.” Each utterance is identified alphabetically to represent the location of focus groups (G: Georgia, C:

Table 1 Thematic content analysis based on the Theoretical Domains Framework (TDF)

TDF domains ^a	Number of questions	Utterances	Reduce ^b (%)	Increase ^c (%)	No influence (%)	Specific beliefs	Themes
Nature of the behaviors	2	88	45 (51.1)	35 (39.8)	8 (9.1)	7	Lumbar x-ray utilization
Skills	3	1	0 (0)	0 (0)	1 (100)	1	None identified
Beliefs about capabilities	3	106	70 (66)	31 (29.2)	5 (4.7)	5	Capabilities; ease of ordering test
Motivation & goals	5	50	28 (56)	17 (34)	5 (10)	4	Intrinsic motivations
Beliefs about consequences	4	334	93 (27.8)	211 (63.2)	30 (18.9)	15	Consequence of ordering lumbar x-rays; attitudes
Environmental context and resources	2	41	16 (39)	25 (61)	0	3	Environmental resource; Signs within the clinic
Social influences	2	128	37 (29)	62 (48)	19 (13.3)	6	Influence of others' opinions (colleagues, patients); influence of organization and new literature
Emotion	2	4	1 (25)	1 (25)	2 (50)	2	Own emotions
Knowledge	7	86	39 (45.3)	33 (38.4)	14 (16.3)	6	Awareness of the guidelines; knowledge of evidence
Memory, attention, and decision process	4	77	67 (87)	10 (13)	0 (0)	8	Factors that influence decision; ease of decision
Social/professional role & identity	4	133	39 (29)	67 (50.4)	27 (20.3)	12	Professional role; professional norms; professional agreement
Behavioral regulation	5	91	91 (100)	0 (0)	0 (0)	12	Ways to reduce testing; barriers; organizational changes; post intentional behavior
Total	43	1,139	526 (46.2)	492 (43.2)	109 (9.6)	88	23

^aTDF domains are presented in the order in which questions were asked in the focus groups. ^bUtterances perceived to reduce x-ray utilization (facilitators).

^cUtterances perceived to increase x-ray utilization (barriers).

California, O: Ontario, Q: Quebec) and numerically to represent specific focus groups. (Please see Additional file 3 for detailed coding of specific beliefs within all TDF domains.)

Beliefs about consequences

Fifteen specific beliefs mapped to this domain. Most participants indicated that the risk of missing a spinal pathology or anomaly were significant disadvantages of managing uncomplicated back pain without x-rays. Many participants took x-rays because of perceived risks of adverse treatment effects or fear of litigation, to help monitor patient conditions, and to improve patient compliance.

Beliefs likely to increase x-ray ordering (barriers)

“The problem is that we perform a service that could injure someone and we certainly want to know what we are dealing with before we start.” (G1)

“What about exposure to liability? If you don’t have an x-ray where you missed a diagnosis.” (C1)

“I think x-rays also help with the type of treatment I am going to use if there is an anomaly like a transitional segment or presence of a disease will change the way I treat the patient.” (O)

Other participants commented on the financial motivation of routine x-ray, onsite imaging, and x-ray-driven techniques.

“I think there might be a financial incentive to order x-rays, financial is definitely part of that. I might add as a whole you are pretending that you’re doing a more thorough job if you have onsite imaging.” (Q)

In contrast, participants expressed a number of beliefs about the benefits of managing nonspecific back pain without x-rays, including minimizing ionizing radiation exposure to patients, reducing costs, minimizing adverse events from further investigation, and avoiding labelling of patients.

Beliefs likely to decrease x-ray ordering (facilitators)

“Benefits to not using x-rays are cost savings and minimizing patient radiation exposure.” (C1)

“... like any tests you may have equivocal findings and need further investigation that could lead to further medical procedures such as a biopsy and those carry their own risks, so there’s always that risk

of complications related to further investigations.” (Q)

“[Other benefits] include avoiding creating anxiety to patients from incidental findings on routine x-rays...” (G2)

Many providers believed guidelines were designed to further restrict practice. Furthermore, US participants suggested that provider networks restrict their autonomy if they don’t conform to their standards by assigning providers to lower tier levels. Maintaining the highest tier level to reduce administrative burden was perceived to be important by most participants:

“...if you’re not top tier, you are so mired in paperwork and the reimbursement is so low.” (G2)

“Our management protocols tend to be dictated by [the third-party payers] reimbursement policy to a certain degree.” (G2)

“Your incentive is to keep the network ... happy so you don’t get kicked off the panel.” (C2)

[Regarding third-party payers’ adoption of guidelines] “I don’t think that reducing ionizing radiation exposure is the argument, I think it comes down to cost reduction.” (G1)

Social/professional role and identity

Twelve beliefs were grouped under the domain of **social/professional role and identity**. While many participants addressed the perceived need for professional autonomy, several others suggested that the lack of standardization, beliefs about the possibility of visualizing chiropractic subluxations on x-rays, and insufficient knowledge and skills of colleagues in the profession were problematic. In addition, many providers were concerned with the credibility of the chiropractic profession (e.g., importance of appropriate x-ray ordering). About half of all participants were trained to take x-rays routinely; however, only a minority believed that x-ray-driven techniques to establish treatment protocols were an integral part of current chiropractic practice. Agreement with available diagnostic-imaging guidelines widely varied among participants.

Beliefs likely to increase x-ray ordering (barriers)

“I want to be able to make my own decision; that’s why I got into chiropractic.” (G2)

“As a profession we take a lot of criticism... Some would say you’re not real doctors, you don’t take x-rays.” (G2)

“Some providers look for subluxations and the only way to tell for sure is to take an x-ray. . .” (G1)

“It’s just a guideline and you know it could help you in the decisional process but I don’t think it should be viewed as some holy bible of how to take x-rays, you know, it should be taken with a grain of salt.” (Q)

Beliefs likely to decrease x-ray ordering (facilitators)

“If we reduced x-ray utilization rate, we could present ourselves to other professions and to the world as being efficient, doing the right thing for the right reason.” (G2)

“I don’t do x-ray listing or x-rays based on a certain technique, I don’t think that’s necessary.” (C2)

“Those x-ray guidelines make a tremendous amount of sense to me.” (C1)

Social influences

Social influences, including the influence of formal training, colleagues, patients, and the health management organization’s/institution’s guidelines, protocols, or requirements, appear to be important factors to consider.

Beliefs likely to increase x-ray ordering (barriers)

“... I remember the teacher saying ‘always x-ray the point of pain. So if a person comes in with first episode low-back pain or says my wrist has been really sore for three months, you better x-ray their wrist. I saw that as a ‘cover my butt’ or liability management.” (O)

“Patients who are worried of having something serious and are asking for x-rays do influence my decision to order films.” (Q)

Beliefs likely to decrease x-ray ordering (facilitators)

“When the HMO [health management organization] started publishing their guidelines, I would say it did influence me to take less x-rays.” (C1)

Beliefs about capabilities

Four specific beliefs about capabilities were identified, including participants’ self-efficacy, self-confidence, past experience, and clinical uncertainty in managing uncomplicated back pain without x-rays.

Beliefs likely to increase x-ray ordering (barriers)

“A disadvantage of not taking those films is not having the comfort level you need to treat patients.” (G2)

“I’ll use whatever tool I need including x-rays to get that information and make the right diagnosis.” (G1)

Beliefs likely to decrease x-ray ordering (facilitators)

“If during the history taking and physical examination the patient doesn’t show any red flags, I feel very confident to treat my patients without x-rays.” (Q)

Knowledge

The domain of knowledge was reflected by beliefs relating to the following: awareness of the existence of the x-ray guidelines, familiarity and agreement with the content of the guidelines, knowledge of conflicting guideline recommendations, and whether or not it was felt that the level of evidence was sufficient for proposed recommendations. Three participants admitted not being aware of the existence of the evidence-based guidelines, and three others had minimal knowledge of their content. In addition, some felt their colleagues were not up to date or had insufficient training in critical reading of the literature.

Beliefs likely to increase x-ray ordering (barriers)

“One of the fundamental problems that we have is that there’s not the depth of research in some of these areas for the guidelines to be terribly credible.” (O)

“How can two different organizations looking at the same data to generate guidelines could come up very with different recommendations? To me, this raises a lot of questions on the ethics of some people developing guidelines.” (C1)

Beliefs likely to decrease x-ray ordering (facilitators)

“... most of us are willing to go along with what the science says and if the science says unequivocally that taking x-rays is to the patient’s detriment unless six visits have gone by and the whole situation. . .” (O)

Differences between American and Canadian participants

A secondary objective was to compare responses from American and Canadian participants. Specific beliefs and key domains were generally similar for both countries (Table 2). Nevertheless, important differences included perceived threat of litigation among US participants and ASH Network’s incentives to conform to evidence-based

Table 2 Distribution of utterances perceived to influence x-ray-ordering practice comparing American and Canadian participants

TDF domains	USA				Canada			
	Reduce ^a (%)	Increase ^b (%)	Noinfluence (%)	Utterances (N)	Reduce ^a (%)	Increase ^b (%)	No influence (%)	Utterances (N)
Nature of the behaviors	43 (61.4)	22 (31.4)	5 (7.1)	70	2 (11)	13 (72)	3 (17)	18
Skills	0 (0)	0 (0)	1 (100)	1	0 (0)	0 (0)	0 (0)	0
Beliefs about capabilities	62 (73.8)	21 (25)	1 (1.2)	84	8 (36)	10 (45)	4 (18)	22
Motivation & goals	25 (59.5)	12 (28.6)	5 (11.9)	42	3 (38)	5 (63)	0 (0)	8
Beliefs about consequences	73 (31.3)	136 (58.4)	24 (10.3)	233	75 (74)	20 (20)	6 (5.9)	101
Environmental context & resources	10 (40)	15 (60)	0 (0)	25	6 (38)	10 (63)	0 (0)	16
Social influences	29 (27.1)	60 (56.1)	18 (16.8)	107	18 (86)	2 (9.2)	1 (4.8)	28
Emotion	1 (25)	1 (25)	2 (50)	4	0 (0)	0 (0)	0 (0)	0
Knowledge	20 (40)	20 (40)	10 (20)	50	19 (53)	13 (36)	4 (11)	36
Memory, attention, & decision process	39 (92.9)	3 (7.1)	0 (0)	42	18 (72)	7 (28)	0 (0)	25
Social/professional role & identity	34 (33.3)	48 (47.1)	20 (19.6)	102	1 (3.2)	19 (61)	5 (16)	31
Behavioral regulation	61 (100)	0 (0)	0 (0)	61	30 (100)	0 (0)	0 (0)	30
Total	397 (48.4)	338 (41.2)	76 (9.3)	821 (72.1)	180 (58)	99 (33)	23 (7.5)	308 (27)

^aUtterances perceived to reduce x-ray utilization (facilitators). ^bUtterances perceived to increase x-ray utilization (barriers).

practice (beliefs about consequences). Other differences related to organizational influences elicited through the domains of beliefs about consequences and, to a lesser extent, social influences and social/professional role and identity. Inquiries into the perceived influence of organizations were discussed in the context of quality-improvement strategies offered by the provider network, such as continuing education seminars, posting of the diagnostic-imaging guidelines on the organization's website, and educational letters. Lastly, Canadian participants admitted ordering routine back x-rays for a majority of new patients. In contrast, American chiropractors generally reported referring fewer than 50% of acute low-back pain patients (nature of the behavior).

Discussion

Summary of findings

Focus groups using the TDF [58] identified the complex interplay between chiropractors' beliefs about implementing diagnostic-imaging guidelines for adult spinal disorders in private practice. Our findings were consistent with previous research exploring factors influencing general practitioners' [33,38,43,73-79] and chiropractors' [5,19,47] use of guideline recommendations. Factors perceived to strongly influence lumbar x-ray-ordering practice clustered in five theoretical domains: beliefs about consequences (consequence of ordering x-rays and attitudes about the guidelines and professional experiences), social/professional role and identity (professional role, norms, boundary, autonomy, professional dignity or wanting to do the right thing, and agreement), social

influences (influence from formal training, colleagues, publication), beliefs about capabilities (particularly when the patient's diagnosis is unclear), and knowledge of the evidence base.

Having very few utterances coded in the skills domains in our study could be due to a number of reasons, including the low relevance of the domain as x-ray ordering differs from performing highly technical procedures, the nature of the questions themselves, coders' interpretation of the domains and associated constructs, and coding within multiple domains. Only four utterances were elicited in the domain of emotion. Possible reasons for this low number of utterances include the following: (1) seeing back pain patients with a range of pain and disability levels may fail to elicit strong emotional reactions after several years in practice as one gains self-confidence (beliefs about capabilities) and (2) focus groups may not be well suited to assess emotions among a group of healthcare professionals. Past reviews of barriers to guidelines and implementation have grouped attitudinal and emotional barriers together [33,78]. In the current study, statements implying lack of self-efficacy, confidence, sense of authority, and accurate self-assessment were classified under the TDF domain of beliefs about capabilities.

Influence of professional identity

Heterogeneous and contradictory beliefs were expressed by participants about professional identity and cultural authority (social/professional role and identity). We observed disagreements among chiropractors about the scope of

practice, professional autonomy, choice of lexicon (concept of chiropractic subluxation), and role of evidence. Professional identity remains an important source of tension between chiropractors [65,80,81], with paradigm differences (experiential vs evidence-based practice) likely driving other domains toward intention to manage back pain with or without x-rays. Such influence seems particularly important on the domains of **beliefs about consequences** (practice style, including x-ray-driven techniques), **social influences** (choice of literature and continuing education seminars), **knowledge** (guideline agreement), **memory attention and decision making** (taking x-rays if results are likely to change treatment protocols), and **nature of the behaviors** (ordering x-rays routinely or only in presence of red flags). A recent review of factors influencing health professionals' intentions and behaviors found **social/professional role and identity** to be a substantial determinant of intention [82]. The domain of **social/professional role and identity** may act as a mediator of x-ray ordering among chiropractors. This will be further considered in a predictive study.

Geographical variations

The main differences observed between US and Canadian chiropractors included perceived threat of litigation and HMO incentives to conform with evidence-based practice, two factors known to influence adoption of guidelines in general [47,73,75,83] and utilization of imaging studies in particular [84]. Perceptions of organizational influences, reimbursement system, incentives for particular procedures, resources available to help implement CPGs, and logistics were elicited through the domains **beliefs about consequences** and, to a lesser extent, **social influences** and **social/professional role and identity**. For instance, maintaining a higher tier was deemed important as it provided increased practice latitude by reducing the volume of paper work needed to justify ordering of spine x-rays. Providers' perceptions of the ASH tier administrative system fell under the domain of **beliefs about consequences**. Corresponding constructs (reinforcement/punishment/consequences, incentives/rewards, and sanctions/rewards) may be important to consider when designing a behavior-change intervention among chiropractors enlisted with networks of providers and HMOs.

Study limitations

While this study has provided valuable insight into the factors that may influence routine x-ray-ordering practices of chiropractors, there were several limitations. Recruitment was challenging, and two potential Canadian participants failed to show up. As a result, the number of participants in focus groups conducted was relatively small, and inclusion of other participants may have provided different beliefs either in favor of or against the

targeted behavior [85]. This is particularly relevant to our secondary objective aiming to compare responses from American (n = 14) and Canadian (n = 7) chiropractors. However, the age, gender, and years in practice were representative of North American chiropractors. Further, the diversity of views, attitudes, and beliefs and the wide range of self-reported behavior (from rarely using x-rays to routinely doing so) reported by practitioners in four distinct geographical locations suggest that this may not be a major problem [86].

It is likely that other important barriers to guideline implementation would have surfaced had we also interviewed patients. Interviews of back pain sufferers suggested that lumbar x-rays were very important [87]. Patient's views and expectations may considerably influence physician ordering and can be a barrier to appropriate use [38,41,43]. In the current study, chiropractors admitted ordering nonindicated x-rays to maintain trust, limit conflict, reduce patient anxiety, or protect professional dignity. Various strategies have been suggested to assist clinician and back pain patient encounter [87]. Engagement of patients in the decision process is another avenue to explore [88].

One important challenge when coding focus groups into the theoretical domains was the lack of clear definitions and the overlaps between multiple domains (e.g., **beliefs about consequences** and **motivations and goals**), rendering consensus difficult at times. In addition to using two independent coders with different professional backgrounds who reconciled differences at every step, findings were reviewed by a behavior psychologist (JJF) with in-depth knowledge of the TDF. Coding and subsequent agreement greatly improved after the first two transcripts. Validation of the TDF has resulted in a refined version addressing these shortcomings [89].

Although care was taken so participants would not get cues to answer in certain ways, agreement with other participants for fear of feeling marginalized by colleagues or to please the interviewer is a known weakness of focus groups. To account for social desirability, the interviewer asked participants to clarify nonverbal communication and coders considered patterns (e.g., changed or reversed statements after hearing from others, recurrent comments, and themes supported or rejected by more than one participant) when linking utterances with specific beliefs. Discussions after each focus group suggested the interview guide did not feel repetitive and questions relating to domains felt relevant to the participants. Furthermore, the frequency of responses throughout focus groups (Table 1) indicated that participants remained engaged despite the number of questions asked (43 with prompts) and associated length of focus group interviews (around 90 minutes).

Conclusion

Very few studies have attempted to examine potential barriers and facilitators to implementing guidelines among chiropractors using the TDF. Our study provides new insight into beliefs of chiropractors with respect to managing back pain without x-rays and theory-based factors likely to influence compliance. Adherence to diagnostic-imaging guideline recommendations appears to be influenced by a number of factors likely to either increase or decrease ordering of lumbar x-rays. Relevant TDF domains included beliefs about consequences, social/professional role and identity, social influences, belief about capabilities, and knowledge. These domains appeared to be important due to the high frequency of beliefs, presence of conflicting beliefs, and evidence of strong beliefs likely to impact the behavior. Study findings can be used to inform the development of a theory-based predictive survey to further explore determinants of routine lumbar x-rays for uncomplicated back pain and test whether social/professional role and identity is a mediator of x-ray ordering among chiropractors. Results may also assist in designing a tailored intervention to improve guideline adherence.

Additional files

Additional file 1: Summary list of potential barriers and enablers identified in the literature.

Additional file 2: Interview topic guide for focus groups.

Additional file 3: Elicited beliefs within TDF domains.

Competing interests

AES is an associate editor of *Implementation Science*; JMG is a member of the Editorial Board of *Implementation Science*.

Authors' contributions

JMG, JF, AES, and The Canada Prime Plus team conceived the original study and acquired funding. AEB adapted the study design, contributed to the development of the interview guide, conducted all interviews, and analyzed and interpreted the data. AMP contributed to the development of the interview guide, and analyzed and interpreted the data. JF interpreted the analysis. JMG contributed to the development of the interview guide and supervised the research group. AEB wrote the manuscript, and all authors commented on the sequential drafts of the paper and agreed upon the final manuscript.

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CHAPTER FIVE

PSYCHOLOGICAL THEORIES TO PREDICT INTENTION IN

CHIROPRACTIC

Identifying factors predictive of managing patients with low back pain without using x-rays among Ontario chiropractors: Applying psychological theories to evidence-based clinical practice.³

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Abstract

Background: Psychological models of behaviour change have been used successfully to understand and predict behaviour in a number of settings. The application of such models is less well established in the context of chiropractic. This study aimed to identify theoretically based modifiable factors that predict whether chiropractors manage patients with low back pain without ordering lumbar spine x-rays.

Methods: A mailed survey with psychological measures was collected from a random sample of Ontario chiropractors working in private practice in Canada. The outcome measures were behavioural intention and behavioural simulation (scenario decision-making). Explanatory variables included constructs from motivational theories (Theory of Planned Behaviour (TPB), Theory of Interpersonal Behaviour (TIB)), action theories (Operant Learning Theory (OLT) and Planning (action and coping)), and two other constructs: personal moral norm and habit as measured by the Self-Reported Habit Index (SRHI). Multiple regression analyses were conducted to examine the predictive value of each theoretical model individually for simulation and intention outcomes.

Results: 34.3% of chiropractors returned completed questionnaires. Overall, TPB, TIB, followed by personal moral norms and OLT best explained self report behavioural simulation. Theory level variance explained was: TPB 59.3%, TIB 56.7%, personal moral norm 49.1%, OLT 48.9%, action planning 28.1%, and SRHI 27.1%. Constructs from TPB and TIB best explained behavioural intention. Theory level variance explained was: TPB 85.5%, TIB 83%, OLT 61.8%, and SRHI 43%.

Conclusion: This study provides evidence that psychological theories can predict a proxy measure of clinical behaviour among chiropractors. These models explained up to 59% of the variation in behavioural simulation and up to 85% in intention to manage back pain patients without x-rays.

Background

Routine imaging for uncomplicated back pain is not associated with clinically meaningful benefits but can lead to harms [1, 2]. Thus, in the absence of clinical features suggestive of serious low-back problems, national guidelines recommend against using lumbar x-rays in low-back pain patients [3, 4]. In spite of this, large variation in lumbar spine x-ray requests from chiropractors has been observed [5-7], with lumbar x-ray use ranging from 12.3% in chiropractic out-patient teaching clinics in Canada [8] to 63% among Ontario chiropractors in general practice [6, 9].

Despite substantial human and financial investments, Clinical Practice Guidelines (CPGs) continue to be underutilized [10]. While printed educational material such as guidelines have the potential to promote evidenced-based practice [11], passive dissemination strategies tend to result in a small to modest improvements in the process of care among physicians [12, 13], and chiropractors (INSERT Bussières et al. ITS study). Most studies evaluating the effectiveness of guideline dissemination and implementation strategies of evidence-based guidelines have not explicitly used theory [14]. The effectiveness of guideline implementation strategies appears to vary across different clinical problems, contexts, health care professions, and organizations [15-18]. Since implementing guidelines often requires clinicians to change their behaviour, it may be helpful to base implementation interventions on explanatory models that can potentially identify targets for change. Few studies used a mixed-method design or existing theories, models or framework to strengthen the design of barrier assessment [16]. Theory-based approaches to barrier assessment facilitate the use of systematic methods for designing interventions, and thus are more likely to be effective to improve guideline adherence and promote behaviour change [19-21]. Psychosocial theories have been successfully applied to explore potential determinants of behaviour change [22-25],

and to help design targeted interventions to change clinical practice [26-28]. Few studies have explored the usefulness of theoretical constructs among chiropractors [29].

The current study aimed to investigate the use of psychological theories to predict factors associated with chiropractic management of back pain patients without x-rays. Factors were drawn from *motivational theories* (Theory of Planned Behaviour (TPB) [30], Theory of Interpersonal Behaviour (TIB) [31], and Moral norms (considered both as part of TIB and as a single construct) [32, 33]), *action theories* (Operant Conditioning/learning [34], Planning comprising action planning [35] and coping planning [36], and Self-Reported Habit Index (SRHI) [37]). TIB encompasses many of the behavioural determinants found in TPB, but also considers moral, social, and cultural factors found particularly important in the study of healthcare professionals [33]. Psychological theories, described elsewhere [38-40], were chosen because they have been rigorously evaluated in other settings, they explain behaviour in terms of factors that are amenable to change (e.g., individuals' beliefs and perceived external barriers); include non-volitional components (i.e., they assume that individuals do not always have complete control over their actions), and vary in their emphasis [38].

The objective of this study was to identify psychological theories and related theoretical constructs that predict in chiropractors, clinical behavioural simulation (decision to order lumbar x-rays as measured by five clinical scenarios) and behavioural intention to manage uncomplicated back pain without lumbar x-rays.

Methods

Design and participants

The design was a predictive study to identify which theoretical constructs predicted self-reported proxy measures of behaviour (behavioural simulation and behavioural intention) measured by a single postal questionnaire.

Participants were chosen from a target population of 2400 licensed chiropractors from the Ontario Chiropractic Association membership online directory using a list of random sampling numbers from a statistical program. Eligible participants had not participated in a related qualitative study [41].

Predictor measures

The study tested the predictive power of 13 theoretical constructs about clinical behaviours and conditions. Theoretically-derived measures were developed following standardized operationalization protocols of TPB [42], TIB [31, 39, 40], OLT [34], Action Planning/Coping Planning [43, 44], and SRHI [37]. Although habit was included in our investigation as part of OLT (which includes evidence of habit and self-report past behaviour), behavioral frequency measures do not tap the heart of the habit construct, automaticity [37]. SRHI is a validated measure that has been used on its own to assess habit strength in a variety of behaviours [45]. Similarly, personal norms and moral norms were included as part of TIB. However, on the basis of recent theoretical development [32], we pre-specified personal moral norm, combining personal norm and moral norm, as a single construct to predict behavioural simulation. The impact of personal moral norm on clinical behaviours has been previously reported [40, 46]. Table 1 provides a summary of predictive measures used in this study and definitions of the theoretical

construct. Questions measuring these constructs were informed by focus groups with 21 North American chiropractors, each lasting 90 minutes [41], and adapted from previous theory-based questionnaires [24, 25, 38, 40, 47]. The instrument is available as Additional File 1 (Appendix 5). Unless otherwise stated, all questions were rated on a seven-point scale from 'strongly disagree' to 'strongly agree'. Survey responses served to identify variables that can predict targeted behaviours.

Professional and practice characteristics

Professional and practice-related factors such as numbers of years in practice, practice setting, and owning imaging equipment have been shown to be determinants of inter-doctor variation among general physicians [33, 48-51], and chiropractors (Bussi eres et al. Descriptive study). We included a limited set of professional and practice characteristics to assess their influence on chiropractors' decision making process: Age, gender, years in practice, employment (full/part time), number of chiropractors in the practice, location (urban, suburban, rural, remote area), setting (professional/medical/office building, private clinic, home, other), and onsite imaging services.

Outcome measures

Two proxy outcomes were included in the analyses. *Behavioural simulation* used responses to written clinical scenarios – a common means of testing clinical decision-making in professional education. Clinical scenarios have been used to assess practice variation across countries, health care systems, health conditions and clinical specialties [8, 52-54]. The second outcome was a theoretically-derived measure, *behavioural*

intention, because there is also evidence supporting intention as a consistent predictor of subsequent behaviour [20, 33].

Behavioural simulation

Vignettes presented scenarios. Key elements that may influence chiropractors' decisions to manage uncomplicated back pain without lumbar spine x-rays were identified from the literature [3, 6, 7, 23, 55, 56], recommendations from a diagnostic imaging guideline intended for use by chiropractors and other primary care providers [57], expert opinion of the clinical members of the research team, and the initial focus groups with chiropractors. The elements included: clinical elements (onset, duration of episode, pain distribution, associated leg pain, activity of daily living, physical examination including neurological deficit, motor or sensory loss, general health history, co-morbidity, past investigations, visit frequency, treatment response, time off work, and previous episodes); chiropractor factors (responsiveness to patient, organizational pressure, busy clinic, knowledge of patient); and patient factors (age, gender, occupation, self-care, anxiety, distress, and desire for x-ray). Five clinical scenarios with various levels of complexity were constructed by choosing between three and eight of these elements to describe a plausible situation of a patient presenting to a chiropractor. Decisions to manage uncomplicated back pain patient without referring for lumbar x-rays was the appropriate behaviour [2, 4]. Respondents were asked to decide whether they would refer for x-rays (score = 1) or not (score = 0). The total number of x-rays referrals was summed across the five scenarios. Lower scores (i.e., fewer x-ray referrals) reflected stronger likelihood to appropriately manage back pain patients [42].

Behavioural intention

Three questions assessed general intention to manage back pain patients without lumbar spine x-rays: In the next 3 months: *'I will try to manage patients with uncomplicated back pain without lumbar x-rays; I intend to manage patients with uncomplicated back pain without lumbar x-rays; I plan to manage patients with uncomplicated back pain without lumbar x-rays.* Higher mean scores reflected stronger intention to manage patient without lumbar x-rays.

Procedure

The face validity of the theory-based questionnaire was assessed by experts in behavioural and implementation research and pilot tested in a sample of 11 North American chiropractors. Study participants were sent an invitation pack (letter of invitation, questionnaire consisting of psychological and demographic measures, as well as a prepaid return envelope). Following the Dillman method [58], three postal reminder cards were sent to non-responders at three, six, and eight weeks, and reminder packages (reminder letter, a questionnaire and a reply-prepaid return envelope) were sent at five, seven and 10 weeks. Upon reception of completed questionnaires, participant names were entered for a draw/lottery to win one of ten \$250 gift cards from Amazon.

Sample size and statistical analysis

The target sample size of 200 was based a minimum of 154 subjects when undertaking multiple regression analysis with 13 predictor variables or 208 to test individual predictor to detect an effect size of 0.40 with an alpha of 0.05 and 95% power [59]. Taking the

larger figure as the target sample size and assuming a conservative response rate of 30% for the survey, we distributed 750 questionnaires. The representativeness of the study participants was examined by comparing their demographics with available demographics of the 2011 Canadian Chiropractic Research Databank [60], maintained by the Canadian Chiropractic Association, and the 2012 Ontario Chiropractic Association database [61].

Data were analyzed using SPSS (version 18) [62]. Univariate descriptive statistics were examined for accuracy of data entry. The internal consistency of the measures was tested using Cronbach's alpha. If the alpha coefficient was less than 0.6, then questions were dropped from each measure to achieve the highest possible Cronbach's alpha [63]. For constructs with only two questions, a correlation coefficient of 0.25 was used as a cut off for acceptable consistency. The relationship between predictive and outcome variables was examined within the structure of each of the theories, using Pearson correlation coefficients. Multiple regression analyses were used to examine the predictive value of each of the theoretical models separately.

Ethics approval

The study was approved by the Ottawa Health Research Ethics Boards (2011509-01H).

Results

We received completed questionnaires from 231 of 674 eligible chiropractors (34.3% response rate (Figure 1)). Respondents provided usable data on intention (227) and behavioural simulation (225). Numbers included in analysis vary between outcome measures because complete case analysis was used.

Table 2 displays provider and practice characteristics of participants. Seventy percent of participants were males. The mean (SD) age was 43 (11) years with an average (SD) of 16 (11) years in practice. The majority were in full time practice (75.7%), working in an urban (71.2%), suburban (27.9%) or rural (0.9%) setting. About one third of chiropractors were in solo practice (32.2%). 19% of participants indicated having onsite imaging services. The demographics of this sample (age, gender, school attended, employment, practice setting, and having onsite imaging) was compared to the Canadian Chiropractic Research Databank (CCRD) for the year 2011 (N=1061) [60, 61], and the Ontario Chiropractic Association (OCA) database for the year 2012 (N=3244) [60, 61]. Overall, there were no significant differences with members of the OCA (Table 2).

Descriptive statistics for the independent variables are provided in Table 3.

Across the five case scenarios where an x-ray was not indicated according to the guideline, at least 60% of chiropractors suggested that they would order x-rays for one of the scenarios. Behaviour simulation was normally distributed around the mean (1.98, SD=1.52) (Table 4).

Relationship between the two outcome measures

The two outcome measures (behavioural simulation and intention) were significantly correlated with each other: Pearson's r was - 0.76 ($p < 0.01$).

Predicting behavioural simulation

The individual constructs that predicted self-reported behavioural simulation were: intention and perceived behavioural control (indirect measure) (TPB); intention and habit (TIB); evidence of habit, self-reported past behaviour, and anticipated consequences

(OLT); action planning (Planning), personal moral norm and Self-Reported Habit Index (SRHI). Neither direct perceived behavioural control nor coping planning predicted behavioural simulation (Table 5).

The results of the theory-level analyses are shown in Table 5. The TPB explained 59% of the variance in behavioural simulation, TIB explained 57%, OLT explained 49%, Planning (action) explained 28%, SRHI explained 27%, and personal moral norms explained 49%.

Age was highly correlated with years in practice ($r=0.93$) and therefore excluded from main analysis. Two professional and practice characteristics predicted behavioural simulation (Table 6).

Number of years in practice and onsite imaging services explained 15% of the variance.

Predicting behavioural intention

With the range of possible scores for intention of 1 to 7, the mean (SD) was 5.3 (1.9). The individual constructs that predicted behavioural intention were: subjective norm, attitude, perceived behavioural control (TPB); moral norm, social normative beliefs, affect, perceived consequences, personal normative beliefs (TIB); evidence of habit, anticipated consequences, self-reported past behaviour (OLT); and SRHI (Table 5).

The results of the theory-level analyses are shown in Table 4. The TPB constructs explained 85% of the variance in behavioural intention, TIB explained 83%, OLT explained 62%, and SRHI explained 43%.

Number of years in practice and onsite imaging services also explained 19% of the variance in intention (Table 6).

Discussion

Using a theory-based postal questionnaire, we examined the predictive power of factors from a range of psychological models for two proxies of behaviour, self-reported behavioural simulation and intention, in the context of lumbar x-ray ordering by chiropractors in Ontario. Despite the lack of clinical information suggestive of a serious pathology, approximately 40% of participants would have ordered lumbar x-rays across the five case scenarios (mean=1.98, SD=1.52). These results suggest a persistent evidence–practice gap among Ontario chiropractors.

Overall interpretation

Results provided an empirically-supported, theoretical basis to design interventions to support the adoption of the evidence-based recommendation to reduce lumbar x-ray use for uncomplicated back pain among chiropractors. Although chiropractors had strong intentions to manage back pain patient without x-rays, this did not necessarily translate into low x-ray utilization. This suggests that interventions to increase intentions are unlikely to be successful. Thus, it would seem appropriate to design an intervention that aims to translate behavioural intention into action, using models that focus on post-motivational elements. Individuals who increase their levels of cognitions and skills such as self-efficacy beliefs and planning may be better suited to execute intended changes in behavior and subsequently maintain these changes [43, 64-67].

There was a stepwise decrease in the proportion of variance explained by intention to and behaviour simulation (Table 4). Past reviews have shown a similar pattern, with social cognitive models explaining 44% of self-reported behaviour and 59% of intention [33]. The proportion of variance explained were higher for predicting

behavioural simulation than other recent studies [24, 25, 56], but within reported range for intention (R^2 varied from 0.14 to 0.91) [33].

Behavioural simulation was significantly predicted by constructs relating to control beliefs (TPB), intention to refer (TPB and TIB), perceived consequences (TIB), prior plans about managing back pain patients without x-rays (action planning), habitual management of these patients without x-rays (OLT and TIB), high reported frequency of past behaviour (OLT), habit (automaticity) (SRHI). Personal moral norms emerged as substantial determinants of behavioural simulation. Our analysis provides further empirical support for its inclusion as a single construct to explain clinical behaviours [40, 46]. Facilitating conditions did not explain a significant proportion of behavioural simulation. This suggests that perceived environmental factors were not associated with the decision to manage back pain patients without x-rays. The low mean score for Self-Reported Habit Index did not suggest an element of automatic/ habitual behaviour in this group of providers although it moderately predicted behavioural simulation. Coping planning did not predict behavioural simulation.

All constructs significantly predicted intention. TPB and TIB tended to explain a greater proportion of variance in intention than constructs from OLT and SRHI. This was not simply due to the greater number of predictors. For TPB, the strongest variable was subjective norm, indicating that the chiropractors who perceived social pressure toward managing back pain patients without x-rays reported positive intention to do so. Attitude and perceived behavioural control also predicted intention. For TIB, moral norm (perceptions of the correctness of the behaviour) and social normative beliefs (the perceptions of the 'culture' in the reference group) were the strongest predictors. A recent review of social cognitive theories found both constructs were significant predictors of professional intention [33]. Further, both attitudinal beliefs (comprising

affect and perceived consequences) and personal normative beliefs significantly predicted intention. Personal normative beliefs (formed by personal norm, self-identity, and professional norm) [68] was also found to influence physician intention to both adopt telemedicine [39] and use HTA recommendations [40]. For OLT, evidence of habit was the strongest predictor, indicating that regular management of these patients without x-rays was associated with a favorable intention to do so. Similarly, SRHI was positively associated with intention.

Greater years in practice and having onsite imaging were associated with lower intention to manage back pain patients without x-rays and increased the likelihood to refer for x-rays. As with physicians, older clinicians who have been in practice for longer [69, 70] and those with onsite imaging equipment or owners of imaging facilities [49-51, 71, 72] tended to have lower adherence to standards of care and higher x-ray ordering rates.

Strengths and limitations

This study contributes to establishing a theoretical base to better understand chiropractors' ordering of spine x-rays. To our knowledge, only one ongoing Australian study [73] has used health psychology theories to explore determinants of lumbar x-rays in this group of professionals. However, our study has a number of limitations.

First, we only used proxy measures of behaviour (behavioural simulation and intention) as routine data on x-ray utilization rates were not available. The predictive value of theoretical constructs to explain actual behaviour still needs to be established.

Second, while case scenarios are thought to be valid, feasible and inexpensive tools to measure quality of health care [74], a review highlighted that evidence concerning proxy measures of clinicians' behaviour is still limited and suggested they are

not necessarily accurate indicators of actual performance, meaning clinicians can underestimate or overestimate their performance for some clinical actions [52]. Referrals for x-rays were higher in scenarios which included: presence of nerve root compression, time off work, failure to improve within two weeks of care, and patient demand for x-rays. Overall, it appears that case scenarios adequately framed the behaviour of interest and were clinically sensible.

Third, in a similar study assessing determinants of lumbar spine x-ray referrals among general physicians [56], TBP and OLT explained only a small proportion of behavioural simulation (R^2 of 13.4 and 0.26 respectively) and intention (R^2 of 0.25 and 0.81). We propose three potential explanations for the high R^2 obtained in the current study: (1) A high R^2 may reflect a problem of 'over-fitting,' i.e. a perfect but meaningless solution [75]. Other studies, both with small or large samples, have reported high R^2 in the prediction of behavioural intention among healthcare professionals based upon psychosocial theories [39, 40, 46, 76]; (2) Types of professions and healthcare setting appear to be important, with significant differences observed in the variance explaining intention to implement guidelines [77]. Further, a recent review [33] suggested that the best prediction of behaviour was found for health care professionals other than physicians and nurses, whereas intention was best predicted among nurses. Chiropractors' beliefs and attitudes about managing back pain without x-rays [41] may explain some of the observed differences in variance; (3) Alternatively, good psychometric properties or better formulated survey questions may explain high R^2 obtained. Survey questions were informed by preliminary work using focus groups with chiropractors to identify key construct domains likely to influence the behaviour of interest [41], and a number of studies investigating a range of theories across different behaviours in various professions [24, 25, 38, 40, 47].

Fourth, one TIB construct was poorly operationalised. Personal identity, formed by multiplying two items ('beliefs about characteristics' and the importance of these characteristics), had low internal consistency (Alpha = 0.4). Reasons for this may be that one item was not self-referent (did not refer to "I" or "me" or "my" behaviour), and two items did not specifically address the behaviour under investigation ('I am concerned about the quality of patient care' and 'I consider my style of practice mainstream'). Personal identity alone (the degree of congruence between the individual's perception of himself/herself and the characteristics he/she associates with the realization of the behaviour) had wording with poor correspondence with the wording of the intention items. Combining personal identity with personal norms (feeling of personal obligation regarding the performance or not of a given behaviour) and professional norms (related to the integration by the self of the specific normative pressures of one's professional group) significantly improved the predictive validity of this construct in explaining chiropractors' intentions.

Fifth, the response rate was poor if within the range of recent surveys of health professionals [24, 25, 39, 40, 56, 78]. Despite an increased evidence base for methods for improving the response rates to postal questionnaires, there has been a steady downward trend in clinicians' response rates to surveys [79]. Surveys of chiropractors have reported a lower mean response rate (52.7%) [80], and a recent survey in Australia also obtained a rate of 37% [81]. Written comments received from a few providers suggested they chose not to complete the questionnaire because of their strong views in favour of routine x-rays. Although study participants were representative the target population [60, 61] (Table 2), we cannot exclude the possibility of response bias and should be cautious about generalizing results. However, this may be less problematic as

this was an exploratory analysis aiming to test the predictive ability of theories to explain variations in behavioural intention and simulation.

Last, in cross-sectional studies, the causative aspects of the theories and constructs remain untested. We cannot rule out the possibility that behaviour caused intention or that a third unmeasured variable or “spuriousness” is the potential cause of both intention and behaviour [82]. In addition, repeated or ongoing behaviours such as x-ray ordering practice, are situations in which correlations are more likely to be inflated by the effects of behaviour on perceptions [82]. However, the fact that constructs are acting as the theories propose is promising for the utility of applying psychological theories to explain clinical behaviour among allied professionals.

Implications for research

Despite these limitations, the present study contributes considerably to the understanding of acceptance of evidence-based recommendations on the use of spine x-rays by chiropractors. This model has the advantage of considering cultural variations in the formation of behaviours [31]. Chiropractors have a wide range of views and practices [83] and items measuring theoretical constructs must be adapted to their reality. This was done by applying a qualitative approach [41] to the development of the questionnaire. Moreover, the current study successfully assessed the validity of a number of models to predict chiropractors' management of back pain without lumbar x-ray. This research supports previous findings that types of health professionals influence the efficacy of prediction of intention and behaviour [33, 77].

Conclusion

Theoretical constructs explained a very large portion of the variance in both behavioural simulation and intention. OLT, personal moral norm, TIB and TPB explained between 49% and 59% of the behavioural simulation, while OLT, TBP and TIB explained between 62% and 85% in the intention to manage back pain patients without x-rays. However, there remain conceptual challenges in operationalizing aspects of TIB. Interventions to influence appropriate use of x-rays among chiropractors that includes both motivational components to increase levels of cognitions and strategies to bridge the intention-behaviour gap may have greater likelihood of success.

Competing interests

Martin Eccles is editor-in-chief of *Implementation Science*; Anne Sales is an associate editor of *Implementation Science*; Jeremy Grimshaw is a senior advisory board member of *Implementation Science*; Melissa Brouwers is a member of the Editorial Board of *Implementation Science*.

Authors' Contributions

JMG, JJF, AES, MPE, LL and The Canada Prime Plus team conceived the original study and acquired funding. AEB adapted the study design, contributed to the development of the survey questionnaire, distributed the survey, analysed and interpreted the data. AMP contributed to the development of the survey questionnaire and data collection. JJF, MPG, MPE, LL and GG contributed to the development of the survey questionnaire and interpreted the analysis. JMG contributed to the development of the survey questionnaire and supervised the research group. AEB wrote the manuscript and all

authors commented on the sequential drafts of the paper and agreed upon the final manuscript.

Table 1: Summary of the predictive measures

Theory of Planned Behaviour (Ajzen, 1991)		
Constructs (number of items)	Example Item(s)	Definitions
Behavioural intention (3)	I intend to manage patients with Uncomplicated Back Pain (UBP) without Lumbar X-rays (LXr)	Individual's motivation regarding the performance of a given behaviour
Attitude (Att): Direct (6); Indirect (5 behavioural beliefs (bb) multiplied by 5 outcome evaluations (oe) items. The score was the mean of the summed multiplicatives (multiplicities?).	Direct: Managing patients with UBP without LXr would be (not at all beneficial/very beneficial) Indirect: Managing patients with UBP without LXr would increase the risk of missing an underlying pathology (bb: very unlikely/very likely) x Missing an underlying pathology (oe: un/important)	Att: overall positive or negative affect associated with the behaviour bb: reflect beliefs that might affect the behavior of our target population oe: evaluation of the importance of each bb
Subjective Norm (SN): Direct (3); Indirect (3) normative beliefs (nb) multiplied by 3 motivations to comply items (mtc). The score was the mean of the summed multiplicatives.	Direct: Most people whose opinion I value would approve if I manage patients with UBP without LXr Indirect: My patients expect me to manage patients with UBP without LXr (nb) x How motivated are you to do what patients' think you should (mtc: not at all/very much)	SN: reflect what important people think a person should do and what important people actually do. nb: beliefs with respect to reference groups (e.g., patients, colleagues, organizations and management) mtc: motivation to comply with the values of the reference groups.
Perceived Behavioural Control (PBC): Direct (3); Indirect (4 control beliefs (cb) multiplied by 4	Direct: I can overcome all obstacles, whatever they may be, to managing patients with UBP without LXr	PBC: perceptions of one's ability to perform the target behaviour given perceived facilitators and

perceived power (pp) to inhibit/enhance behaviour items. The score was the mean of the summed multiplicatives.	Indirect: I find it difficult to manage patients with UBP without LXr if the patient appears disinterested/not responsive to advice (cb) x how likely are you to manage patients with UBP without spine x-rays when the patient is disinterested/not responsive to advice (pp: very unlikely/very likely)	barriers that are occurring cb: belief that makes it more or less likely that the respondent will perform the target behavior pp: whether the belief makes the behavior easier or more difficult to perform
Theory of Interpersonal Behaviour (Triandis 1980, 1989)		
Attitudinal beliefs comprise two dimensions: Affect (6)	Same as TPB Attitude direct	Emotional state that the performance of a given behaviour evokes for an individual
Perceived consequences (5)	Same as TPB Attitude indirect	Individual's perception of the instrumental consequences of the behaviour
Moral Norms (3)	It would be acting as a responsible person for me to manage patients with UBP without LXr	What is considered the morally right thing to do
Social Normative Beliefs (S): Formed by 3 Role beliefs (Rb) and 3 Normative beliefs (Nb) items (S= $\sum(Rbw1 + Nbw1)$).		S: perceptions of the `culture' in the reference group
Role beliefs (Rb=3)	I consider that managing patients with UBP without LXr is appropriate for a chiropractor with my years of experience	Extent to which an individual thinks someone of his or her age, gender, and social position should/should not behave

Normative beliefs (Nb=5)	In the next 3 months, my colleagues would disapprove/approve if I was to manage patients with UBP without LXr	Internalization by an individual of referent people's or groups' opinions about the behaviour
Personal normative beliefs (P): Formed by 3 Personal Norms (Pers), 3 Self-identity (Si) and 3 Professional Norm (Pro) items ($P = \sum(Persw1 + Siw1 + Prow1)$).		
Personal Norms (3)	It is my responsibility to order LXr of patients with UBP prior to undertaking manual therapy	Pers: feeling of personal obligation regarding the performance of a given behaviour
Personal moral norm comprise personal norm and moral norm		Considers moral factors, such as anticipated regret and moral norm (personal values, principles, responsibility)
Self-identity (Si): 3 beliefs regarding characteristic of x-ray users (bc) multiplied by 3 importance of these characteristics for themselves (imp_c). The score was the mean of the summed multiplicatives.	A chiropractor who manages patients with UBP without LXr is concerned about the quality of patient care (bc) x I am concerned about the quality of patient care (imp_c)	Si: degree of congruence between the individual's perception of self, the goals associated with the realization of the behaviour, and the behaviours that the person does or does not engage in
Professional Norms (3)	I consider that it is appropriate for a chiropractor working in a private clinic to manage patients with UBP without LXr	Pro: individual's assessment of how one should behave given his belonging to a specific professional group
Facilitating conditions (8)	Having onsite imaging would influence (impact) managing patients with UBP without LXr in my	Perception of conditions that that can ease or impede the realization of the behaviour

practice (very unlikely/very likely)

Self-Reported Habit Scale (srhs) (12)

In my clinic, when patients present with UBP, managing them without LXr is something that belongs in my routine

How routine a given behaviour has become, i.e. the frequency of its occurrence

Habit (2) (same as evidence of habit)

When I see a patient with UBP, I automatically consider taking LXr

Operant Learning Theory (Skinner, Blackman, 1974)

Anticipated consequences (3)

If I manage patients with UBP without LXr, it is highly likely that the patient will be worse off overall

Perceived positive or negative consequences of a behaviour for the individual

Self-reported Past Behaviour (1)
(scaled from 0 to 10)

From memory, for approximately how many of your last 10 patients who presented with UBP as a new patient did you manage without LXr

Frequency of past behaviour

Evidence of habit (2)

When I see a patient with UBP, I automatically consider taking LXr

Evidence of habitual behaviour

Planning (Gollwitzer 1993, Scholz 2008)

Action planning (3)

Action: I have a clearly formulated plan in mind for how I will manage patients with UBP without LXr

Explicit plans about when and where a goal intention will be achieved

Coping planning (3)

Coping: I have readily available alternative strategies regarding what to do when challenges disrupt my initial plan to manage patients with UBP without LXr

Strategies to prioritize the intended over the habitual responses when obstacles or barriers are faced

Table 2. Provider and practice characteristics of respondents compared to demographic information for Ontario chiropractors

Characteristic (% unless stated otherwise)	Sample (N=231)	CCRD (2011)§ (N=1061)	OCA (2012)‡ (N=3244)	Sample vs. OCA * (Z, X ² , P value)
Gender				
Male	69.7%	66%	65%	(1.55, 0.06)
Female	29.9%	34%	35%	
Missing Values	0.4%			
Age in Years [Mean, (SD)]	43.8 (11.1)	N/A	42.0	(2.62, 0.006)
Years in Practice [Mean, (SD)]	16.2 (11.1)	N/A	13.9	
Less than 20 years	69%	69%	76%	
School attended				(2.52, 0.16)
CMCC (Toronto)	74%	78%	75%	
Other	26%	22%	25%	
Employment				(2.22, 0.01)
Full time (> 25 hours)	77.5%	76%	71%	
Part time (between 1-24 hours)	21.6%	24%	29%	
Missing Values	0.9%			
Location		N/A	N/A	
Private Clinic	58.8%			
Pro/Medical building	28.1%			
Home	3.5%			
Other ^a	9.1%			
Missing Values	0.4%			
Setting				(X ² =9.50, 0.051)
Urban	70.6%	61% (> 100,000 pop)	76.5%	
Suburban	27.7%	28% (10,000-99,999 pop)	23.3%	
Rural	0.9%	11% (< 10,000 pop)	0.2%	
Missing Values	0.9%			
Onsite imaging services (Yes)			N/A	(1.52, 0.06)
Yes	81%	84%		
No	19%	16%		
Solo providers	32.2%	31%	N/A	

^a = Strip mall, gym, corporate health, rehab clinic, country club, other; N/A = Not available; Pop = Population
 § Canadian Chiropractic Research Databank (Ontario province only for 2011), maintained by the Canadian Chiropractic Association; ‡ Ontario Chiropractic Association database 2012; ¥ Finite population correction was applied for testing equality of two proportions.

Table 3. Descriptive statistics

Theory	Predictive Constructs	N	Alpha	Mean	SD	Completed Responses[‡]
<i>Theory of Planned Behaviour</i>	Attitude direct	6	0.93	5.2	1.7	220
	Attitude indirect	10	0.79	27.5	13.7	225
	Subjective Norm direct	2	0.64	5.4	1.8	228
	Subjective Norm indirect	6	0.69	15.7	11.3	226
	Intention	3	0.94	5.3	1.9	227
	PBC direct	2	0.61	4.8	1.7	228
	PBC indirect	8	0.91	23.5	15.8	212
<i>Operant Learning Theory</i>	Self-Reported Past Behaviour	1	-	7.3	3.5	225
	Evidence of habit	2	0.74	5.9	1.8	228
	Anticipated consequences	3	0.61	5.0	1.6	225
<i>Theory of Interpersonal Behaviour</i>	Affect ^a	6	0.74	5.3	2.3	220
	Perceived consequences ^b	10	0.79	27.5	13.7	225
	Social norms ^c	8	0.63	5.2	1.5	219
	Personal norms	3	0.77	5.8	1.7	228
	Personal identity ^d	6	0.43	25.0	13.4	226
	Professional norms	3	0.87	5.2	1.9	225
	Facilitating Factors	8	0.76	3.3	1.9	214
	Habit	2	0.74	5.9	1.8	228
	Moral Norm	3	0.78	4.8	2.0	226
<i>Planning</i>	Action Planning	3	0.79	5.7	1.5	225
	Coping Planning	3	0.70	4.9	1.6	222
<i>Other</i>	Habit (Self-Report Habit Index)	12	0.85	3.7	1.9	217

N = final number of items; Alpha = Cronbach's; means and SDs; ‡ = Number of respondents.

PBC = Perceived behavioural control; ^a Affect and ^b Perceived consequences are the same items as attitudes direct and indirect respectively; ^c Social norms is formed by adding role beliefs and normative beliefs. ^d Personal identity is formed by multiplying beliefs about characteristics by the importance of those characteristics. Habit is the same as evidence of habit.

Table 4. Mean, CI, SD, x-ray count and Percentage (95% confidence interval) and Mean/median (SD) of the resulting appropriateness score

	Case 1	Case 2	Case 3	Case 4	Case 5	Sum
N Valid	228	227	227	228	227	1137
Missing	0	1	1	0	1	3
No x-ray: N	200	193	75	129	86	683
(%, 95% CI) §	(87.7%; 83.6-92.0)	(85%; 80.9-89.8)	(33%; 27.1-39.1)	(56.6%; 51.1-63.9)	(37.9%; 32.0-44.0)	(60.1%; 57.2-62.9)
X-rays: N	28	34	152	99	141	454
(%, 95% CI) §	(12.3%; 8.0-16.4)	(15%; 10.2-19.1)	(67%; 60.9-72.9)	(43.4%; 36.4-48.9)	(62.1 %; 56.0-68.0)	(39.9%; 37.1- 42.8)
						Mean (SD):1.98 (1.52)
						Median: 2

§ N (%, 95% CI) = Count (percentage, 95% Bootstrap Confidence Interval), Mean/Median (SD) = Standard Deviation of sum of cases.

Table 5. Predicting (simulation and intention) by psychological theory: correlation and multiple regression analysis

Theory	Predictive Constructs	Behavioural Simulation					Behavioural intention				
		<i>r</i>	Beta	R ² (adj)	df	<i>F</i>	<i>r</i>	Beta	R ² (adj)	df	<i>F</i>
<i>Theory of Planned Behavior</i> 1	Intention ^a	-0.76**	-0.66***								
	PBC direct	-0.58**	-0.01								
	PBC indirect	-0.51**	-0.19***	0.59	3, 199	98.9***					
	Attitude direct						0.78**	0.26***			
	Attitude indirect						0.71**	0.05			
	Subjective Norms direct						0.85**	0.48**			
	Subjective Norm indirect						0.16*	0.03			
	PBC indirect						0.72**	0.22***			
						0.49**	0.03	0.85	6, 192	151.5***	
<i>Theory of Interpersonal Behavior</i>	Intention ^b	-0.76**	-0.62***								
	Facilitating Factors	0.17*	0.06								
	Habit	-0.67**	-0.16*	0.57	3, 199	89.3***					
	Affect						0.78**	0.23***			
	Perceived consequences						0.69**	0.12**			
	Social Norms						0.83**	0.29***			

Theory	Predictive Constructs	Behavioural Simulation					Behavioural intention				
		<i>r</i>	Beta	R ²	<i>df</i>	<i>F</i>	<i>r</i>	Beta	R ²	<i>df</i>	<i>F</i>
		(adj)					(adj)				
	Personal Normative Beliefs ^c						0.35**	0.07*			
	Moral Norms						0.83**	0.36***	0.83	5, 197	198,3***
<i>Personal Moral Norm</i>	Personal Moral Norms ^d	-0.70**	-0.70***	0.49	1, 208	208.4***					
<i>Operant Learning Theory</i>	Self-Reported Past Behaviour	-0.55**	-0.22***				0.55**	0.17**			
	Evidence of habit	-0.67**	-0.39***				0.76**	0.49***			
	Anticipated Consequences	-0.59**	-0.19**	0.49	3, 208	68.4***	0.66**	0.24***	0.62	3, 214	118.2***
<i>Planning</i>	Action Planning	-0.51**	-0.49***								
	Coping Planning	-0.28**	-0.09	0.28	2, 208	42.1***					
<i>Habit</i>	Self-Report Habit Index	-0.52**	-0.52***	0.27	1, 208	78.6***	0.66**	0.66***	0.43	1, 213	162.5***

* $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$; r = Pearson product moment correlation coefficient; Beta = standardised regression coefficients; PBC = Perceived behavioural control.

¹ Both direct and indirect measures of attitude, SN and PBC (TPB) were included in this study as each have been used to measure these constructs in the literature.

^a Only intention and PBC are entered in this regression equation as only these variables are the proximal predictors of behaviour in this model. ^b Only intention, facilitating factors and habit are entered in this regression equation as only these variables are the proximal predictors of behaviour in this model. ^c Personal Normative Beliefs is formed by Personal norms, Professional norms and Personal identity. ^d Personal Moral Norms is formed by Moral norms and personal norms.

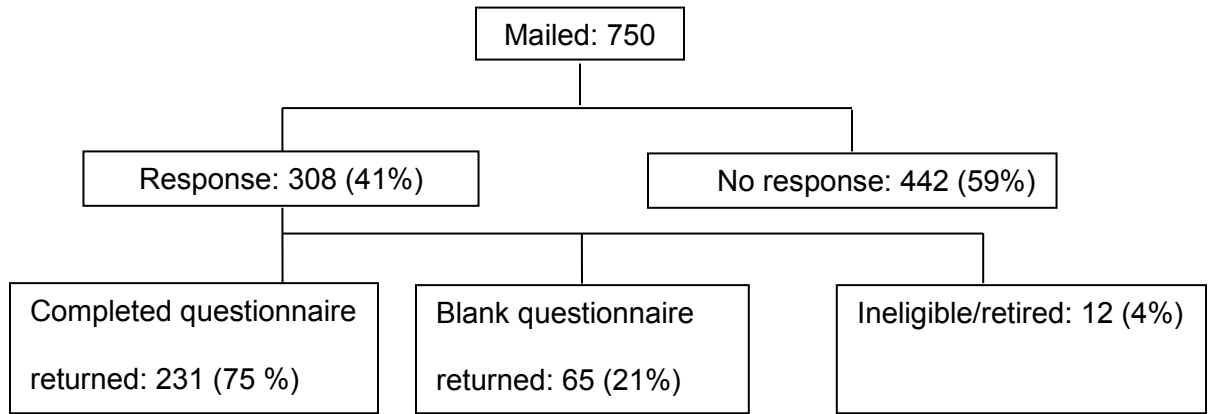
Table 6. Predicting (simulation and intention) by professional and practice variables: correlation and multiple regression analysis.

Parsimonious model

Variables	Predictors	Behavioural Simulation					Behavioural intention				
		<i>r</i>	Beta	R ² (adj)	df	<i>F</i>	<i>r</i>	Beta	R ² (adj)	df	<i>F</i>
<i>professional and practice characteristics</i> ^a	Onsite imaging	0.32**	0.32***	0.15	1/211	14.7***	-0.31**	-0.30***	0.14	2/215	19.3***
	Years in practice	0.25**	0.24***				-0.27**	-0.25***			

^a Seven variables entered in regression model: Gender, onsite imaging services, years in practice, number of providers in practice, location (urban, suburban, rural), setting (pro/med building, private clinic, home, other), full/part time. Pearson correlation for age and years in practice = .93. Age not included in main analysis.

Figure 1. Response rates



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CHAPTER SIX SUMMARY, LIMITATIONS, AND CONTRIBUTIONS

Thesis interpretation, application and suggestions for further research

“Knowing is not enough; we must apply.

Being willing is not enough; we must do!”

Johann Wolfgang von Goethe (1749-1832)

Prelude

Despite various attempts to overcome practitioners' failure to routinely incorporate evidence into practice, little is known on how best to improve practice within specific contexts. This is particularly problematic among allied care professionals and providers of complementary and alternative medicine (CAM) or integrative medicine [1] where less research has attempted to identify and reduce inappropriate care [2]. Research is urgently needed considering the steady increase in CAM over the last two decades [3-5], with an estimated raise in expenditures of 45.2% between 1990 and 1997 in the US [4]. CAM is used by people suffering from a variety of conditions, often in addition to conventional medical care [6]. A representative survey indicated that for the treatment of back and neck pain, a larger proportion of Americans used complementary therapies (54%) than conventional medical care (37%), with chiropractic and massage as a preferred CAM options (20% and 14% respectively) [7]. To date, research efforts have concentrated on understanding chiropractic treatment mechanisms [8], efficacy, cost-effectiveness and safety [9]. Very little health services research has focused on evaluating the effects of dissemination and implementation of clinical practice guidelines to inform chiropractors' clinical decisions.

This thesis aimed to describe variations in spine x-rays, evaluate a simple intervention to reduce overuse of spine x-rays and better understand factors likely to influence the use of recommendations for spine x-rays in the context of chiropractic in North America. Results from study one identified geographic areas to target and structural factors to consider for the design of an intervention to address overuse of x-rays among PN chiropractors. Results from study two found that passive guideline dissemination had a

small impact on x-ray utilization, suggesting the need for more active strategies. Results from studies three and four provide a rationale to inform the development of interventions to increase guideline uptake for managing back pain without x-rays. Documenting current practice patterns, the impact of passive guideline dissemination strategies, and determinants of behaviour is only the beginning of a long process toward the everyday use of evidence-based knowledge in chiropractic practice. We must build on previous interdisciplinary research to undertake further high quality knowledge translation research that will lead to the development of methodology in this field and encourage practitioners to conform to best practices.

This chapter summarizes the individual study results and positions them in the field of KT research, with an emphasis on chiropractic. Key strengths and limitations of the research methods, designs, and data used in this thesis are discussed. Further, the implications of the research for population health and practice are outlined. The last section provides an overview of the steps to design and test a theory-based tailored intervention, and of my program to advance the science of Knowledge Translation (KT).

Summary of research findings

In Chapter One, a narrative review of the literature made the case that further work is needed to address overuse of spine imaging among North American chiropractors by testing and refining strategies from the rapidly developing field of KT.

In Chapter Two, I analysed the baseline rates and variations of x-ray ordering practices over a 12 month period among 6946 chiropractors contracted with one of the largest provider of complementary health care networks for health plans in the US. Very few studies have described practice profiles of chiropractors in an established provider network [10-12]. Results suggested overuse of spine x-rays and wide geographic variations persistent across this PN. The rate of immediate spine x-rays was approximately 20% across the network, with variations ranging from 10% in the state of Oregon to 47% in Georgia. A limited number of provider (gender, chiropractic school attended, years in practice, and employment) and practice (geographical location, practice setting, office type) factors explained x-ray ordering by American PN chiropractors.

In Chapter Three, I undertook interrupted time series analysis using segmented regression of routinely collected data to test whether web-based dissemination of an imaging guideline reduced chiropractors' use of spine x-rays. Passive guideline dissemination was associated with a stepwise reduction in the use of x-rays by American chiropractors enlisted with a PN (5.26% relative decrease), but no change in the underlying trend. To my knowledge, this is the first study to document with a robust methodology, a decrease in use of spine x-rays after web-based dissemination of

Printed Educational Materials (PEM) among chiropractors. Although the dissemination of this guideline had a small impact on clinical practice, this is likely important at a population level impact (in terms of reduced patient ionizing radiation exposure, further unnecessary procedures and system costs) given the large number of patients seen in the provider network. Results concur with the recent updated Cochrane review that suggests PEM produce in small to modest improvements in process of care [13]. Findings highlight the need for developing active dissemination strategies to further optimise care.

In Chapter Four, I conducted focus groups using the Theoretical Domain Framework (TDF) [14] to explore beliefs about managing back pain without x-rays in a purposive sample of North American chiropractors. The five domains identified as likely relevant were: *Beliefs about consequences, Social/professional role and identity, Social influences, Beliefs about capabilities, and Knowledge*. Findings informed the development of a theory-based predictive survey to further explore determinants of routine lumbar x-rays for uncomplicated back pain (Chapter Five). This study was part of a series of projects using the TDF in different settings and with different clinical conditions, further validating our findings and demonstrating its utility [15]. Use of the TDF may allow better understanding and systematic following of the causal pathways to professional behaviour change.

In Chapter Five, I explored whether psychological theories predicted variations in chiropractors' intentions and simulated behaviours related to the management of back pain without spine x-rays using a postal questionnaire among a random sample of Ontario chiropractors. Six psychological models explained up to 59% of the variation in

behavioural simulation and up to 85% of the intention to manage back pain patients without x-rays. Overall, the Theory of Planned Behaviour (TPB), the Theory of Interpersonal Beliefs (TIB), and the Operant Learning Theory (OLT) best explained behavioural simulation and intention. This study provides evidence that psychological theories can predict proxy measures of clinical behaviour among chiropractors.

A summary of the main determinants of spine x-ray utilization uncovered using mixed methods is displayed in Figure 1. Of interest, two characteristics, years in practice (Provider Factors) and having onsite imaging (Practice Factors), explained a small portion in the variance of the two proxies of behaviour. Patient and System Level Factors were not specifically assessed in this thesis. However, focus group participants suggested that clinical features, severity of the condition, presence of co-morbidity, and patient demand influenced their decision to use x-rays. Participants also suggested that care setting (US provider network vs. private practice in Canada) and type of reimbursement system, medical-legal environment, and availability of advanced imaging, also played a role. Although it is assumed that a number of these factors likely apply to chiropractors working in other settings (e.g., workers and automobile injury, industry, Veterans Affairs, public healthcare system), their relevance should be formally assessed. Studies aiming to gain a better understanding of views from patients and policy decision makers regarding chiropractors' use of x-rays would be helpful.

Figure 1. Determinants of spine x-ray use among North American chiropractors

Determinants of spine x-ray use among chiropractors

PROVIDER FACTORS

Sociodemographics gender, chiropractic school, years in practice, Employment.

Key Theoretical Domains

- Beliefs about consequences
- Social/Professional roles & Identity
- Subjective norms
- Belief about capabilities
- Knowledge of guidelines

Predictors of behavioural simulation and intention

- Theory of Planned Behaviour
- Theory of Interpersonal Behaviour
- Operant Learning Theory
- Action Planning
- Personal moral norm
- Habit (SRHI)

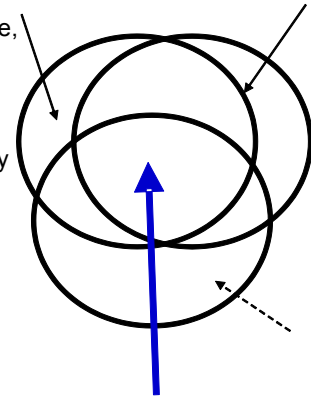
PRACTICE FACTORS

(US practice network)

- Practice location: Midwest/South US census regions
- Office type: free standing clinic
- Practice setting: urban/suburban
- Onsite imaging

PATIENT/SYSTEM FACTORS

- Clinical features, severity, co morbidity
- Care setting (provider network vs. private practice)
- Reimbursement/provider Tier
- Medical-legal environment
- Availability of advanced imaging



Decision about use of spine x-rays

Overall strength and limitations of the research

Strengths and limitations of each of the four studies presented in this thesis were discussed in the relevant individual chapters. The following section presents the methodological strengths of the thesis, including: (1) studies conducted in two different health care settings, (2) the use of various sampling strategies, and (3) the use of mixed method designs from diverse disciplinary fields. I then discuss the broader strengths and limitations of the thesis with a focus on the use of a theory-based approach for barriers assessment, and research designs and data used in this research.

Methodological strengths

Settings

The importance of framing KT activities within the specific contexts where knowledge is intended to be used has been highlighted [16]. Studies conducted in two different health care settings demonstrated the need for further interventions to improve guideline uptake among North American chiropractors and potential targets for such an intervention. Most chiropractors in the US are enlisted with managed care organizations such as provider networks [17]. PN chiropractors saw patients under pre-specified terms and conditions, including guidelines, protocols, and payment structure. In contrast, a number of Canadian provinces have delisted chiropractic services in the past decades. While most provincial health care plans reimburse chiropractic care for complaints related to automobile or work injuries, this thesis was concerned with managing non-traumatic back and neck pain. Despite these differences between the US and Canada, the majority of North American chiropractors are in private practice, with very few providers working in large teams of professionals or in hospitals.

Exploring chiropractor's determinants of x-ray utilization within a large American PN and two Canadian provinces highlighted a number of differences at the provider, practice, and system level (Chapter Four). For instance, perceived threat of litigation and PN incentives to conform to best practices were concerns voiced by American focus group participants. These factors are known to influence guideline adoption and use of imaging studies among physicians [18-20]. Of interest, Canadian participants admitted having higher rates of spine ordering than their American colleagues. Such differences may be partly attributable to specific PN Clinical Performance System (provider tiering system) designed to improve guideline adherence and reduce x-ray use and may not reflect the rate of use in an unmanaged system. The PN assigned chiropractors to one of six levels based on service utilization including x-ray ordering practice and quality data. Each tier level defines the number of patient visits and services permitted before verification of medical necessity is required. Determining the effect of payment structures within various settings on chiropractor's adherence to guideline would be helpful.

A predictive study among Ontario chiropractors (Chapter Five) identified theoretical constructs to target when considering the design of a behaviour change intervention. A similar ongoing study within the PN will allow a comparison of factors across both settings. Overall, lessons learned will help to inform strategies to improve chiropractic care in North America.

Sampling strategies

An additional strength of this thesis is the use of various sampling strategies. The descriptive and the quasi-experimental studies included a large sample sizes and consecutive patient encounters. For the focus groups, a purposive sample was drawn

from the PN to seek respondents across a spectrum (geographical area, chiropractic school attended, x-ray ordering practice, years in practice, and expertise) to ensure that all viewpoints would be adequately represented. Furthermore, the predictive study used a random sample of Ontario chiropractors selected among members of the Ontario Chiropractic Association providing equal chance to participate.

Use of mixed methods

Few studies have used a mixed-method design based on existing theories, models or frameworks to strengthen the design of barrier assessment in the chiropractic context. We applied qualitative and quantitative methods sequentially to explore potential determinants of behaviour and behaviour change and to provide a rationale for the design of a KT intervention to improve appropriate use of spine x-rays. The use of mixed method designs from diverse fields (epidemiology/health services research - Chapter Two, social evaluation - Chapter Three, and psychology - Chapters Four and Five), provided new insights to a complex phenomenon that is beyond the scope of a single study, and potentially reduced biases associated with a mono-method approach to research [21, 22].

Theory-based approach for barrier assessment

Increasingly, the literature reflects growing awareness of factors relating to the social, organizational and economic contexts that influence the successful uptake of knowledge [23-25]. As a result, researchers are encouraged to use theories to understand barriers, design complex multilevel interventions, and explore mediating pathways and moderators to advance the KT science [26-29]. Recent evidence lends support to the use of theory in implementation research [30].

Rigorous methods underpinned by theory were used to explore potential determinants of behaviour and behaviour change and to provide a rationale for the design of a KT intervention to improve appropriate use of spine x-rays. While use of such approach is recommended prior to embarking on more expensive confirmatory studies [31], a systematic review of studies evaluating interventions to improve the use of imaging for musculoskeletal conditions found this was rarely done [32].

The following discussion focuses on the Theoretical Domain Framework (Chapter Four), and psychological theories selected for the predictive study (Chapter Five). The observed low response rate and substantial intention–behaviour gap are also addressed.

Theoretical Domain Framework (Chapter Four)

Study three contributed to the growing experience of applying the Theoretical Domain Framework (TDF). It has been published as one in a series of articles documenting the

development and use of the TDF in different settings, professional groups, investigating different clinical behaviours, further demonstrating its utility[15].

The TDF was formulated to enhance the usefulness of behavioural theory to researchers in a range of disciplines. Determinants of behaviours should be identified across a broad range of domains. Further, the large number of partly overlapping theories of behaviour makes it difficult to select the most appropriate theory. Using the TDF is an efficient theory derived method of rapidly identifying determinants of behaviour across a broad range of domains compared to trying to achieve similar objective using the individual theories that contribute to TDF.

What are the strengths and weaknesses of the TDF?

Two major strengths of the framework are its theoretical coverage and its capacity to elicit beliefs that are potential target for change. The TDF covers a broad spectrum of psychological theories thereby limiting the risk of omitting important areas when exploring factors which may impact decision making regarding the use of evidence in clinical practice. Limitations of the framework include: (1) the TDF is a descriptive framework rather than a theory [15]; (2) inter-coder agreement can be relatively low [33]; and (3) many researchers feel that organizational-level factors are not adequately elaborated [15]. First, the TDF is descriptive as it does not specify relationships between the domains and thus does not generate testable hypotheses. Second, inter-coder agreement was challenging because some of the domains lack clear definitions and the overlaps between multiple domains made consensus difficult at times. Interdisciplinary research teams may benefit from the inclusion of content experts and a health psychologist. Third, domains that arguably focus on organizational-level factors are

Environmental Context and Resources, Social Influences (organizational climate), Social/Professional Role and Identity, (organizational commitment) and Behavioural Regulation (barriers/facilitators). While there appears to be reasonable representation of organizational factors that are relevant to clinical behaviours, insights from other disciplines that arguably are more centrally concerned with organisational and contextual factors such as sociology and organisation psychology are not well represented.

Studies supporting the use of the TDF

Francis (2012) identified 21 studies using the TDF, of which 17 investigated the behaviour of health professionals and four investigated health-related behaviour of members of the public [15]. Recent studies provide support for the use of the TDF to: (1) to investigate determinants of specific clinical behaviours [15], (2) determine if identified key domains predict clinical practice [33], and (3) systematically develop a complex implementation intervention to improve care [34]. Additional support for its use may come from ongoing efforts to identify relevant theories of behaviour change to inform the design of interventions [35] and evaluate the effectiveness of theory-based interventions to improve care delivery [36, 37].

How could the TDF be further improved?

Despite efforts to capture all the relevant theoretical constructs, some may be missing. Other models and theories from psychology, education and other fields have been used to describe behaviour and predict behaviour change [38]. These may prove more useful in the future or may be merged with existing frameworks. An advantage of merging frameworks would be to provide access to a large evidence base from the behaviour-change literature. For example, the Consolidated Framework for Implementation

Research (CFIR) [39] provides a pragmatic structure for analysing complex, interactive, multi-level and transient state constructs by consolidating and unifying key constructs from published implementation theories. There is potential for mapping the TDF domains on to the CFIR inner setting and outer setting. Alternatively, CFIR inner and outer settings may be mapped on to TDF domains. The inner setting includes features of structural, political, and cultural contexts of an organization through which the implementation process will proceed. The outer setting includes the extent to which patient centred care is an organizational priority, how the organization is networked within other external organization, pressure from competing organizations and governmental policies to implement interventions, and external strategies to spread interventions. Such factors may be assessed through interviews and/or surveys of policy decision makers.

Recent attempts to validate the content of TDF framework led to a refined version consisting of 14 domains and 84 component constructs [40]. The domain of 'Nature of the Behaviours' was removed as this reflects the behaviour of interest, while 'Intentions' and 'Goals' replaced the domain of 'Motivation and Goals', and 'Reinforcement', and 'Optimism' were added. Further studies are needed to determine if the revised TDF has successfully addressed shortcomings presented in Chapter Four, namely the lack of clear definitions and the overlaps between multiple domains.

Predictive study (Chapter 5)

Study four contributes to establishing a theoretical base to explore beliefs about factors influencing chiropractors ordering of spine x-rays. To our knowledge, only one ongoing study has applied health psychology theory to explore determinants of imaging in this

group of professionals [41]. The present study provides the foundation to develop and test intervention(s) to promote guideline adherence and thus, for supporting the implementation evidence based chiropractic.

How were theories selected?

Psychological models were selected by the PRIme Plus project because theories had been rigorously evaluated in other settings, they explain behaviour in terms that are amenable to change, and have non-volitional components [42]. For the purpose of the current study, theories were mapped to key TDF domains previously identified through focus groups of chiropractors. Results explained a very large portion of the variations in behavioural simulation and intention to manage back pain patients without x-rays.

What are the implications for research?

The current study successfully assessed the utility of a number of models to predict chiropractors' management of back pain without lumbar x-ray. The integration of the variables presented in Figure 2 summarizes the majority of our findings. The proposed theoretical framework results from a review of factors influencing healthcare professionals' behaviours and intentions based on social cognitive theories [43]. This however does not imply that other factors are not important.

The Theory of Planned Behaviour (TPB), the Theory of Interpersonal Behaviour (TIB), and to a lesser extent, the Operant Learning Theory (OLT) best explained behavioural simulation and intention. TIB encompasses many of the behavioural determinants found in TPB, but also considers cultural, social, and moral factors found particularly important in the study of healthcare professionals [43]. Moral norm (perceptions of the correctness of the behaviour) and social normative beliefs (the perceptions of the 'culture' in the

reference group) were the strongest predictors. A recent review of social cognitive theories found both constructs were significant predictors of professional intention [43]. To our knowledge, the present study is one of the first to document that these are associated with clinicians' x-ray ordering behaviour. This means that, in the context of x-ray ordering, chiropractors might be influenced by what they think others would want them to do (subjective norm) [44], their personal values or the perception of the correctness of the behaviour (moral norm) [45], and by a sense of belonging to a specific group and what they believe a clinician like themselves ought to do (social normative beliefs) [46]. Further, both attitudinal beliefs (comprising affect and perceived consequences) and personal normative beliefs significantly predicted intention. Based on previous work by Triandis, personal normative beliefs are formed by three components: personal norm, self-identity, and professional norm [47]. This construct was also found to influence physician intention to both adopt telemedicine [48] and use HTA recommendations [49].

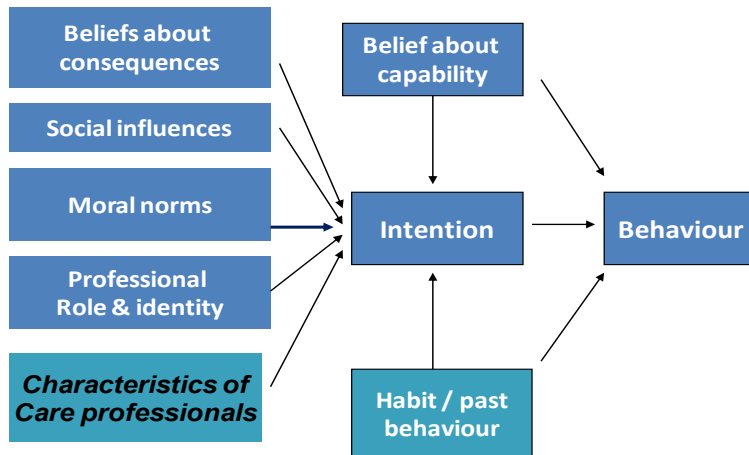


Figure 2. Hypothesized theoretical framework for the study of healthcare professionals' behaviour and intention (Godin, 2008)

Figure 2. Hypothesized theoretical framework for the study of healthcare professionals' behaviour and intention (Godin, 2008)

What are the key limitations?

Low response rate

Despite use of evidence-based strategies to improve response rates to postal questionnaires, there has been a steady downward trend in clinicians' response rates to surveys [50]. Following the Dillman method [51], a random sample of 750 Ontario chiropractors were mailed an invitation card and a postal package (invitation letter, a survey questionnaire and pre-posted reply envelope) a week later. Three postal reminder cards were sent to non-responders at weeks 3, 6, and 8 as well as reminder packages at weeks 5, 7 and 10. Despite using this method, only 230 chiropractors returned their completed survey questionnaire, for a response rate of 34.3%. Although study participants appeared representative of the target population [52, 53], we did not have access to the characteristics of non-respondents. As a result, we cannot exclude the possibility of response bias and should be cautious about generalizing results.

Intention–behaviour gap

It remains uncertain whether behavioural intention to manage back pain without x-rays predicts actual behaviour as routinely collected data on x-ray utilization was not available among Ontario chiropractors. Overall, findings in different fields indicate a rather substantial intention–behaviour gap, with medium-to-large change in intention leading to small-to-medium change in behavior [43, 54]. This is perhaps because when trying to translate intentions into behavior, individuals are faced with numerous barriers such as those identified in the focus group study, including potential consequences of not ordering x-rays (e.g., risk of missing a pathology, avoiding adverse treatment effects), beliefs regarding professional autonomy and credibility, influence of formal training and

patients, self-confidence, guideline awareness, having onsite imaging or habits. Individuals who have developed habitual behaviours become less likely to act on new information, sometimes avoiding information that challenges the present behaviour [55]. Matching the interventions to the identified individual-level barriers may help reduce the intention-behaviour gap.

The substantial intention–behaviour gap further highlights the need to consider structural determinants of behaviour change, such as those identified in the descriptive study. For instance, an interaction was found between school attended and years in practice suggesting that chiropractors continue practicing as they were initially trained. This underlines the long lasting influence of formal training and the challenges in keeping up to date. These conclusions were echoed by focus group participants (Chapter Four) who suggested formal training was an underlying factor of x-ray ordering practice many years later. Strategies to reduce unnecessary x-ray utilisation should consider exploring views from instructors of radiology department within chiropractic schools who train future professionals and are key players in updating program curriculums. Ammendolia et al. surveyed 33 accredited chiropractic colleges worldwide to evaluate guideline adherence [56]. Results suggest greater adherence among teaching institutions than general practice [57]. However, there was still room for improvement as 40% of respondents indicated that there is a role for x-rays in acute low back pain without red flags and an additional 15% were unsure [56, 57]. Similarly, close to 40% of Ontario survey respondents' recommended spine x-rays when non-indicated based on clinical vignettes (Chapter Five). Considering undergraduate programs in North America are subjected to an accreditation process, a policy change to encourage teaching institutions to adopt evidence-based guidelines could potentially have a stronger influence on future health care providers.

Research Designs

This section addresses key strengths and limitations of the research designs used in this thesis.

Cross-sectional study (Chapter Two)

Few studies have assessed service utilization in established chiropractic PNs [10-12], and these used convenience samples. We conducted a cross-sectional study using administrative data on spine x-ray utilization and enrolment information from chiropractors enlisted with one of the largest PN in the US. Results however may not be generalized to non-managed care settings. Further, we did not have patient or system level data that would allow a hierarchical model. Detailed patient information was not available due to the requirement to maintain confidentiality, and the dataset contained limited system level information (e.g., no information on state level policies and regulations, types of payment structures or modes of communication between the PN or professional associations and providers).

Quasi-experimental study (Chapter Three)

To our knowledge, this is the first study to document a decrease in use of spine x-rays after web based dissemination of Printed Educational Material (PEM) among PN chiropractors. An interrupted time series design was used to evaluate the impact of web-based dissemination of an imaging guideline in reducing use of spine x-rays across this PN. This design provides the most robust method of measuring the effect of an intervention when randomized controlled trials are not feasible or when the intervention has already occurred like in this case [58-60].

This simple, likely cost-effective strategy potentially had significant benefits at the population health level (reduced ionizing radiation exposure to patients, fewer further unnecessary investigations, and decrease costs to the system). Our results are compatible with a recent review suggesting an overall small impact of PEM strategies [13]. Formal cost-effectiveness analyses of PEM dissemination strategies are needed.

Similar results may be achieved in Canada if provincial associations and licensing boards were to recommend the use of this PEM to members. However, replication of this study in the Canadian setting will require access to routinely collected actual outcome measures. Oscar, an Open source Electronic Medical Record (EMR) developed at McMaster [61] was recently adapted and implemented at the Canadian Memorial Chiropractic College (CMCC) for use by chiropractic students. Current discussions within the profession to scale up implementation of Oscar across private chiropractic practices suggest similar studies could be conducted in Canada in years to come.

Focus group study (Chapter Four)

We undertook six focus groups among North American chiropractors to explore barriers and facilitators in two different health care settings: an American PN and private practices in two Canadian provinces. The TDF underpinned the interview guide and content analysis.

Limitations included the relatively small sample, not including patients' perspectives, and possibly social desirability. Inclusion of other focus group participants may have provided different beliefs either in favour or against the targeted behaviour [85]. This is particularly relevant to our secondary objective aiming to compare responses from American (n =

14) and Canadian (n = 7) chiropractors. However, participant characteristics were representative of North American chiropractors. In addition, the diversity of views, attitudes and beliefs, and the wide range of self-reported behaviour in four distinct geographical locations suggest that this may not be a major problem. It is likely that other important barriers to guideline implementation would have surfaced had we also interviewed patients. Focus group participants admitted ordering 'non-indicated' x-rays to maintain trust, limit conflict, and reduce patient anxiety. Finally, social desirability (agreement with other participants to please the interviewer or for fear of feeling marginalized by colleagues) is a known weakness of focus groups. To account for this possibility, participants were asked to clarify non-verbal communication and coders considered patterns (e.g., changed or reversed statements after hearing from others, recurrent comments, and themes supported or rejected by more than one participant) when linking utterances with specific beliefs.

Predictive study (Chapter Five)

Very few studies have used psychological theories to explore factors associated with chiropractors' use of lumbar spine x-ray. The results of the focus groups informed the design of a predictive survey. A theory-based postal questionnaire was sent to a random sample of 750 Ontario chiropractors to identify modifiable variables that can predict targeted behaviours and may be prime targets for interventions. While selected models explained a very large portion of the variance in both behavioural simulation and intention, these are proxy measures. Routine data on x-ray utilization rates was not available for Ontario chiropractors. As a result, the predictive value of theoretical constructs to explain actual behaviour still needs to be established.

A further limitation relates to the design itself. In cross-sectional studies, the causative relationships remain untested. We cannot rule out the possibility that behaviour caused intention or that a third unmeasured variable or “confounding” is the potential cause of both intention and behaviour [82]. However, the fact that constructs are acting as the theories propose is promising for the utility of applying psychological theories to explain clinical behaviour among allied professionals.

Data used in this Research

This section discusses key strengths and limitations inherent to the use of administrative data, the risk of spurious associations from regression analyses conducted in this research, and the use of proxy measures of behaviour.

Administrative data (Chapters Two and Three)

Studies one and two had a number of strengths, including a large sample size, inclusion of all patient encounters for spine disorders by chiropractors contracted by one of the largest PN of complementary care across the US, use of objective outcome measures, and a five-year study period for the interrupted time analysis study. Nonetheless, the following limitations need to be considered: (1) appropriateness could not be addressed, (2) we were unable to account for outside referrals, (3) it is unclear if advance imaging were substituted for undergoing x-rays, (4) automated variable selection in regression analyses poses the risk of spurious associations, and (5) the dataset contained limited patient or system level data.

Appropriateness could not be addressed

Appropriateness could not be determined because the administrative database contained no detailed clinical information such as red flags, specific diagnosis or disease severity and no important confounding variables including patient health status and extent of insurance coverage.

Inability to account for outside referrals

The dataset could not account for x-rays referrals to external medical imaging facilities, a behaviour expected by providers without onsite imaging services when patients consult with indicators of serious spine pathology. Nonetheless, sensitive analyses showed similar factors predicted ordering of imaging irrespective of whether (or not) the providers had on site imaging facilities (Chapter Two). Failure to account for outside referrals is less problematic for the evaluation of the impact of web-based guideline dissemination strategies using the interrupted time series analyses (Chapter Three). A sudden change in the number of outside referrals or in x-ray equipments (machines purchased, sold or defective) occurring at the same time as the guideline dissemination is unlikely.

Ordering of advanced imaging tests

A further limitation was that the PN administrative database did not capture ordering of advanced imaging such as CT scans and MRIs. The lower than expected x-ray utilization rate across the PN (Chapter Two) and downward trend observed in the interrupted time series (Chapter Three) could have resulted from advanced imaging tests being substituted for undergoing x-rays, or from chiropractors being more selective in their ordering. The concern that these changes may be due to increases use of advanced imaging is a rival hypothesis that needs to be tested. However, a recent study suggest that spine x-rays are often ordered in addition to advance imaging tests [62].

Risk of spurious associations (Chapters Two and Five)

In regression analysis, automated variable selection (data driven analysis) poses the risk of spurious associations [63]. The alternative is to develop an analysis plan *a priori* with the anticipated direction of association pre-specified for independent variables included in adjusted models. This research was exploratory in nature as few available studies in chiropractic provided *a priori* knowledge or expectation of candidate predictors truly affecting the outcome to inform of variable selection.

Recommended strategies to guard against overfitting include: use of large sample size and few predictors, variable aggregation, avoiding multiple testing (appropriate correction for the number of degrees of freedom), using adjusted R^2 and Bootstrap validation of models (re-sampling technique), and trying to account for important confounding variables [63]. Risks of spurious associations are discussed in relation to both the descriptive and the predictive studies.

As a rule of thumb for shrinkage methods, one can safely consider only problems where there are maximally 10-15 times more candidates than observations[64]. For the descriptive study (Chapter Two), the large sample size (N=6946) and few candidate predictors (m = 15) entered in our model meant that there were 710 cases per predictor. At most, one predictor had a false association. Considering our regression model did not converge for 'states', this variable was aggregated into four census regions. In addition, in an effort to avoid selecting too many variables and overfitting, only those variables that were selected by backward selection procedure (the least harmful choice of automated variable selection) were eligible for entry into the regression analysis.

Further, the significance for the regression models were obtained by using a standard likelihood ratio test comparing each model's deviance to the deviance of a nested simple regression model for the outcome.

For the predictive study (Chapter Five), sample size was determined based on use of 13 predictor variables, requiring a minimum sample of 208 to test individual predictor to detect an effect size of .40 with an alpha of 0.05, 95% power [65]. We conducted a theory level analysis with 230 completed surveys using a maximum of three predictors for behave simulation and five predictors for intention, meaning there were respectively 76 and 46 cases per predictor. In addition, adjusted R^2 were used to estimate what the fit of the model would be if it were fitted against a new dataset. An alternative strategy would have been to fit a full model with a pre-specified direction independent variable. Again, this study was exploratory. Overall, the risk of a spurious association was relatively low.

Proxy measures (Chapters Five)

Actual measure of behaviour was unavailable at the time we conducted the survey study in Ontario. This study provides evidence that psychological theories can predict proxy measures of clinical behaviour among chiropractors. While clinical vignettes are feasible and inexpensive tools to measure quality of health care [66], Hrisos' (2009) review highlighted that evidence concerning proxy measures of clinicians' behaviour including clinical vignettes is still limited and suggested they are not necessarily accurate indicators of actual performance, meaning clinicians can underestimate or overestimate their performance for some clinical actions [67].

This problems may be reduced by careful and rigorous development of clinical vignettes and the method of their presentation [68]. We used the 'Principle of correspondence' or 'TACT' (Target at which action is being directed; Action being performed; Context; and Time) recommended by Fishbein and Ajzen (1975) to help construct scenarios [69]. Referrals for x-rays were higher in scenarios which included: presence of nerve root compression, time off work, failure to improve within two weeks of care, and patient demand for x-rays. Overall, it appears that case scenarios adequately framed the behaviour of interest and were clinically sensible.

Thesis implications

Implication at the population health level

The findings described in this research make three distinct contributions. First, at the population health level, a descriptive study demonstrated rates of spine x-ray ordering and variations in practice which suggest that overuse persists across a large American PN. Results from a recent National survey in the US support these findings [52]. Our results are partly explained by differences in training, beliefs and practice. Results from studies conducted in the Canadian setting suggest similar patterns. For instance, focus group participants in Ontario and Quebec suggested higher x-ray ordering (between 50% to 90%) than participants in California and Georgia (between 10% to 50%). Further, nearly 40% of Ontario survey respondents' indicated they would have recommended spine x-rays when non-indicated based on clinical vignettes. A recent national survey support suggest overuse of spine x-rays persist among Canadian chiropractors with wide variations across provinces [52].

Second, a simple, likely cost effective strategy resulted in a significant small immediate reduction in x-ray use after web-based guideline dissemination in a PN setting. Considering the large number of providers and patients in this PN, this strategy potentially had important population health level benefit [70, 71]. The observed 5% relative decrease (1% absolute change) in x-ray utilization likely resulted in less patient ionizing radiation exposure [71-73], possibly reduced inefficient and potentially inappropriate invasive diagnosis and subsequent treatment [74-76], and had financial benefits at the system level. Although a formal cost analysis was not conducted, web-based dissemination of these imaging guidelines was likely to be cost-effective.

Developing the Diagnostic Imaging Guidelines for Adult Spine Disorders and web posting in three open sources cost less than \$45,000 USD. Considering an average of 9553 new patient exams were performed each month across ASH network after guidelines were disseminated, we estimate direct savings were in the order of \$152,848 USD over the 32-month period (10 fewer spine x-rays/1000 new patient exams x 9553 new patients exams/month x 32 months x average of \$50,00/spine x-rays). Policy decision makers should consider inviting health care providers to review guidelines on websites as an initial step to reduce the evidence-practice gap. While these findings are likely clinically or economically relevant, passive dissemination did not appear to lead to optimisation of imaging rates. There may be opportunities to develop active dissemination strategies to improve population health and healthcare delivery in chiropractic and evaluate their incremental cost effectiveness.

Third, this thesis established a scientific rationale for interventions to translate research findings into clinical practice. We have offered methods to explore determinants of clinical behaviours in chiropractic. For instance, identified key TDF domains and theoretical constructs may inform development of a tailored intervention to increase likelihood of successful professional behaviour change and improve guidelines adherence.

Implication for the chiropractic profession

Context plays a major part in getting research into practice [24, 25]. The context of this thesis, described in Chapter One, suggests five underlying factors likely contributing to the slow adoption of evidence-based principles and practice in chiropractic: 1) the limited research capacity [77]; 2) the perceived value of research, 3) the limited opportunities to interact due to the large proportion of solo providers [52, 78]; 4) the lack of coordination of efforts to closed the evidence-practice gap, and 5) the ongoing ideological debate within the profession over the scope of practice, choices of lexicon, and practice paradigms (alternative vs. evidence-based practice) [79-81]. A majority of these barriers and controversial views were highlighted by focus groups participants (Chapter Four). Pooling existing resources, agreeing on a universal language, and adopting evidence-based principles and practice may speed up the dissemination and implementation of clinical practice guidelines.

This thesis used the example spine x-ray ordering practice to illustrate the preliminary steps to inform the development of a KT intervention to promote guideline adherence and reduce x-ray utilization. In this thesis, a number of approaches served to explore practice patterns and variations, and help understand, explain, and predict determinants of behaviour change among North American chiropractors. Similar methods may be used to address other evidence-practice gaps in chiropractic.

Finally, it could be argued that the findings from studies conducted within the American PN setting using administrative claims data (Chapter Two and Three) cannot be generalized to non-managed care settings. Claims submitted to ASH are subject to a

peer review process supported by evidence-based guidelines, possibly changing providers' behaviour. However, Smith-Bindman (2008) found that the use of imaging services among health maintenance organization (HMO) members closely parallels the trends found in Medicare fee-for service or privately insured populations [62]. As these findings were in a general medical practice setting, further studies should aim to determine if these also apply to chiropractic

Implication at the policy level

Several organizational factors can influence guidelines adherence including work structure, financial and material contexts, work-related activities, training opportunities and communication, work culture, type of management and policies [1]. For instance, compensation for services varies by State and by Health Plan. As acknowledge in the descriptive study (Chapter Two), observed x-ray utilization rates may be partly attributable to specific PN policies (provider tier system) designed to improve guideline adherence and reduce x-ray use and may not reflect the rate of use in an unmanaged system. The PN stratifies providers into six levels based on service utilization including x-ray ordering practice, and quality data. Provider tier ranges from having to submit documentation for medical necessity verification for all services after the first visit (tier 1) to no medical necessity verification (tier 6). Providers can move up or down in tier level following retrospective annual review based on compliance with proposed standard. Tier level was initially entered in regression model as a predictor variable: With the exception of tier 1 (likely due of the small proportion of providers composing less than 1.5% of this category), an inverse relationship was observed between provider tier and inclination to order spine x-rays. This system likely creates an incentive for providers to comply with

the PN guidelines and to be moved to a higher tier level upon review. Maintaining a higher tier was deemed important by American focus group participants (Chapter Four) as it provided increased practice latitude by reducing the volume of paper work needed to justify ordering of spine x-rays. As such, Tier level system acts more as an intervention and was therefore removed from main analyses of the descriptive study. Future studies should aim to explore service reimbursements as strategies to reduce x-ray ordering practice in PN settings.

For a majority of Canadians, chiropractic services are reimbursed by their collective insurance plans. Providers either directly bill patients or submit an insurance form for reimbursement. Payment imposed caps on the number of services covered per year including x-rays likely helps reduce ordering rates. Further improvement may occur if third party payers promoted the use of evidence-based CPGs.

A simple likely cost effective web-based dissemination strategy resulted in a small reduction in x-ray utilization (Chapter Three). Efforts aimed at influencing third party payers to adopt and promote the use of evidence-based guidelines may help further improve process of care. PN policy makers may wish to consider web-posting of the imaging guideline as an initial step to reduce the evidence-practice gap.

Planned future research

The slow adoption of evidence based principles in chiropractic suggests significant opportunities to improve population health and healthcare delivery in chiropractic. More KT research is needed however before we can generalize our findings. Only one ongoing cluster trial evaluated Australian chiropractors' compliance with a CPG to reduce lumbar x-rays for acute lower back pain [82], and results may not be generalizable to PN chiropractors. We conducted a similar predictive study across the PN using a stratified random sample of 1000 chiropractors selected from the descriptive analysis. In this ongoing project, actual behavioural data will be accessed six months after survey completion. Results should help establish the predictive value of theoretical constructs to explain actual behaviour, and clarify the relationship between intention, behaviour simulation and actual behaviour in this setting.

This thesis is the first phase of a planned KT research program into improving KT in chiropractic. I plan to develop international and interdisciplinary collaborations both for guidelines development and related dissemination and implementation projects. One example of such undertaking is the TRiADS (Translation Research in a Dental Setting) in the UK [83]. This multidisciplinary research collaboration, embedded within a guideline development process, that aims to establish a practical evaluative framework for implementing guidelines and to conduct and evaluate a programme of integrated, multidisciplinary research to enhance the science of knowledge translation. This program may be adapted to the chiropractic setting. My recent appointment as an Assistant Professor at McGill University, School of Physical and Occupational Therapy, with a cross appointment in the Department of Epidemiology and Biostatistics will favour

establishing an interdisciplinary research program. In addition, the Canadian Chiropractic Research Foundation (CCRF) Research Professorship in Rehabilitation Epidemiology award focuses on developing evidence-based CPGs for the chiropractic profession in Canada. Academics with clinical training in chiropractic from six North European countries have voiced interest in establishing research collaborations to produce, disseminate and implement CPGs.

This thesis provides the foundations to proceed to intervention development and testing to promote guideline adherence. I present an example of how I could use the findings from my work to date to inform future intervention development. It should be emphasized that these are preliminary thoughts and broader range of experts and stakeholders would be involved when designing an actual intervention. The section ends with a brief presentation of the subsequent phases of my proposed research program.

Systematic approach to intervention design using the TDF

I propose developing an intervention designed to improve guideline adherence and reduce inappropriate use of spine x-rays. The intervention would be developed using a systematic, empirically informed approach in which: (1) a theoretical framework is selected [34, 84, 85], (2) modifiable behavioural antecedents and actual behaviour are identified, (3) targets are mapped on to evidence-based behaviour change techniques by an expert panel of health psychologist [86, 87], and (4) intervention components are operationalised in a format suitable for delivery (i.e., feasible, relevant and acceptable) [88]. French describes a conceptually similar process [34].

The target population is: chiropractors enlisted with an American provider network; the behaviour of interest is 'managing uncomplicated back pain without x-rays'. Secondary analysis of routinely collected data suggested geographical areas to target should include the states of Georgia and Ohio, with x-ray utilization rate of 47% and 41% respectively (Chapter Two). Performance objectives should be established in collaboration with stakeholders. For example, the objective may be to reduce x-ray ordering rate in targeted states by 10% in the next six months after delivering the intervention. The main outcome measures include: (1) actual behaviour data (x-ray ordering rate from the large PN administrative database), and (2) proxy measures of behaviour (behavioural simulation and intention). The intervention is developed using results of focus groups analyzed using the TDF to specify modifiable barriers and facilitators to managing back pain without spine x-rays (Chapter Four). Selection of behaviour change techniques to overcome the barriers and enhance the facilitators will be informed by a matrix to guide the mapping of key theoretical domains to the behaviour change techniques [86]. In addition, a refined taxonomy of behaviour change techniques may help improve the specification of interventions in published reports, thus improving replication, implementation and evidence syntheses [89]. Table 1 displays a matrix for intervention mapping. Techniques, content and mode of delivery are those provided by French (2012) [34].

Table 1. Example of part of a matrix for intervention mapping using the TDF

Examples of barriers/ facilitators of behaviour change (Chapter Four)	TDF domain (Chapter Four)	Theory (Chapter Four)	Techniques judged to be effective in changing the domain (Michie 2008)	Techniques to reduce lumbar spine x-ray ordering (French 2012)	Content (French 2012)	Mode of delivery (French 2012)
Beliefs about the risk of adverse treatment effect if follow guideline	Beliefs about consequences	Theory of planned behaviour	<ul style="list-style-type: none"> • Self-monitoring; Information regarding behaviour, outcome; • Persuasive communication; • Feedback 	<ul style="list-style-type: none"> • Provide education on consequence • Monitoring of consequences of own behaviour; • Barrier identification; • Persuasive communication 	<ul style="list-style-type: none"> • Clinician record number of times they ordered plain x-ray and it didn't change patient management (<i>i.e. x-rays were unnecessary</i>). • Opinion leader presents persuasive message about consequences of behaving in a manner consistent with the key messages. 	<ul style="list-style-type: none"> • Pre-workshop activity; • Facilitated workshop; • DVD
Beliefs about the role of The chiropractor when managing low back pain	Social/ professional role and identity	Theory of planned behaviour	<ul style="list-style-type: none"> • Social process of encouragement, pressure, support 	<ul style="list-style-type: none"> • Persuasive communication; • Provide opportunities for social comparison 	<ul style="list-style-type: none"> • Opinion leaders presents persuasive message about the role of the clinician to minimise harm (from 	<ul style="list-style-type: none"> • Facilitated workshop; • DVD

					unnecessary irradiation from plain x-ray). • Small group work discussion to allow opportunity for discussion of behaviours among peers.	
Perception that patients expect x-rays	Social influences (norms)	Theory of planned behaviour Theory of interpersonal behaviour	• Information provision; • Persuasive communication; • Modeling	• Communication skills	• Peer expert to discuss content of guideline and highlight organizations that endorse it.	• Facilitated workshop; • DVD
Skills and beliefs about capabilities related to reassuring patients that plain x-ray is unnecessary	Beliefs about capabilities	Social cognitive theory Theory of planned behaviour	• Graded tasks; • Increasing skills: problem solving, decision making, goal setting; • Social process; • Feedback; • Self talk; • Motivational interviewing	• Rehearsal (prompt practice)	• Small group activity: participants to take clinical history with a trained simulated patient to identify red flags. Simulated patients trained to expect and apply pressure for chiropractor to order an x-ray. • Discuss after task with feedback from facilitators.	• Facilitated workshop

<p>Low awareness of LBP red flags and skills in how to identify them</p>	<p>Knowledge</p>		<ul style="list-style-type: none"> • Information regarding behaviour, outcome 	<ul style="list-style-type: none"> • Information provision 	<ul style="list-style-type: none"> • Opinion leader/content expert presents information about the guideline key messages. • Algorithm provided for diagnosis of red flags. • Small group activity: participants reword key messages from the guideline to create behaviourally worded specific key messages (who, what, where, when). 	<ul style="list-style-type: none"> • Facilitated workshop; • Opinion leaders; • DVD
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Research program

This thesis represents the first phase of a planned KT research program into improving KT in chiropractic. The overarching objective of my research program is to continue my pursuit towards better transfer of research evidence for chiropractors and aim to extend this to other primary care professionals. In subsequent phases of my research program I will: (1) continue systematic investigation into the identification of determinants that are important to inform intervention design; (2) explore the causal pathways between individual and organizational factors, research uptake, and patient outcomes (to inform intervention design), (3) design and evaluate the effectiveness of theory-based interventions to improve patient outcomes by increasing uptake of evidence-based practice, and (4) assume a leadership role in the development of clinical practice guidelines for the chiropractic profession in Canada.

Summary and conclusions

This population health thesis in knowledge translation research has examined strategies to better understand determinants of x-ray utilization among North American chiropractors. The four studies conducted in this thesis represent the initial steps to inform the development and evaluation of a behaviour change intervention. I have reported on rigorous methods to: (1) assess practice and providers' characteristics, (2) determine baseline rates and variations in spine x-ray ordering, (3) evaluate the impact of disseminating guidelines to optimise spine x-ray ordering, and (4) assess determinants of spine x-ray ordering and potential targets for change prior to the design of a tailored intervention. Findings from this thesis revealed that high spine x-ray use with wide geographic variations persists among chiropractors enlisted in a large American provider network. Results from this thesis also suggest that web-based dissemination strategies of an imaging guideline produced a small impact on x-ray utilization. This thesis has identified perceptions of provider participants about their use of diagnostic imaging for back pain in two settings and has identified barriers and facilitators of behaviour change using a theoretical framework. The thesis also provides evidence that psychological theories can predict proxy measures of clinical behaviour among chiropractors. Generating evidence regarding the determinants of professional behaviour will contribute significant information for the design of theory-based interventions to address evidence-practice gaps in chiropractic. This research has implications for the use of spine x-rays, the direction of knowledge translation efforts to decrease its use, as well as the role of psychological theory to improve chiropractic practice in general.

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APPENDIX 1 THEORETICAL DOMAINS FRAMEWORK

Theoretical domains, component constructs, and eliciting questions for investigating the implementation of evidence-based practice as proposed by Michie et al. (2005)

The interview questions in column 3 illustrate the kind of explanation that might be investigated in each domain. Using these questions to explore behaviour will ensure that no important domain is overlooked, and the results may assist in explaining the behaviour and in designing a behaviour change intervention.

Domains*	Constructs		Interview questions
(1) Knowledge	Knowledge Knowledge about condition/scientific rationale	Schemas, mindsets and illness representations Procedural knowledge	Do they know about the guideline? What do they think the guideline says? What do they think the evidence is? Do they know they should be doing x? Do they know why they should be doing x?
(2) Skills	Skills Competence/ability/skill assessment	Interpersonal skills Coping strategies	Do they know how to do x? How easy or difficult do they find performing x to the required standard in the required context? <i>Diagnostic skills (taking x-rays instead of physical examination)</i>
(3) Social/ professional role and identity	Identity Professional identity/boundaries/role Group/social identity	Social/group norms Alienation/organisational commitment	What is the purpose of the guidelines? What do they think about the credibility of the source? Do they think guidelines should determine their behaviour? Is doing x compatible or in conflict with professional standards/identity? (prompts: moral/ethical issues, limits to autonomy) Would this be true for all professional groups involved?
(4) Beliefs about capabilities	Self-efficacy Control – of behaviour and material and social environment Perceived competence Self-confidence/professional confidence	Empowerment Self-esteem Perceived behavioural control Optimism/pessimism	How difficult or easy is it for them to do x? (prompt re. internal and external capabilities/constraints) What problems have they encountered? What would help them? How confident are they that they can do x despite the difficulties? How capable are they of maintaining x?

			How well equipped/comfortable do they feel to do x?
(5) Beliefs about consequences	<p>Outcome expectancies Anticipated regret Appraisal/evaluation/review Consequences Attitudes Contingencies Reinforcement/punishment/consequences Incentives/rewards Beliefs Salient events/sensitisation/critical incidents</p>	<p>Characteristics of outcome expectancies – physical, social, emotional; sanctions/rewards, proximal/distal, valued/not valued, probable/improbable, salient/not salient, perceived risk/threat</p>	<p>What do they think will happen if they do x? (prompt re themselves, patients, colleagues and the organisation; positive and negative, short term and long term consequences) What are the costs of x and what are the costs of the consequences of x? What do they think will happen if they do not do x? (prompts) Do benefits of doing x outweigh the costs? How will they feel if they do/don't do x? (prompts) Does the evidence suggest that doing x is a good thing?</p>
(6) Motivation and goals	<p>Intention; stability of intention/certainty of intention Goals (autonomous, controlled) Goal target/setting Goal priority Unrealistic optimism</p>	<p>Intrinsic motivation Commitment Distal and proximal goals Transtheoretical model and stages of change</p>	<p>How much do they want to do x? How much do they feel they need to do x? Are there other things they want to do or achieve that might interfere with x? Does the guideline conflict with others? Are there incentives to do x?</p>
(7) Memory, attention and decision processes	<p>Memory Attention Attention control</p>	<p>Decision making</p>	<p>Is x something they usually do? Will they think to do x? How much attention will they have to pay to do x? Will they remember to do x? How? Might they decide not to do x? Why? (prompt: competing tasks, time constraints)</p>
(8) Environmental context and resources	<p>Resources/material resources (availability and management) Environmental stressors</p>	<p>Person x environment interaction Knowledge of task environment</p>	<p>To what extent do physical or resource factors facilitate or hinder x? Are there competing tasks and time constraints? Are the necessary resources available to those expected to undertake x?</p>
(9) Social influences	<p>Social support Social/group norms Organisational development Leadership Team working</p>	<p>Organisational commitment/alienation Feedback Conflict – competing demands, conflicting</p>	<p>To what extent do social influences facilitate or hinder x? (prompts: peers, Social/group norms managers, other professional groups, patients, relatives) Will they observe others doing x (i.e. have role models)?</p>

	<p>Group conformity</p> <p>Organisational climate/culture</p> <p>Social pressure</p> <p>Power/hierarchy</p> <p>Professional boundaries/roles</p> <p>Management commitment</p> <p>Supervision</p> <p>Inter-group conflict</p> <p>Champions</p> <p>Social comparisons</p> <p>Identity; group/social identity</p>	<p>roles</p> <p>Change management</p> <p>Crew resource management</p> <p>Negotiation</p> <p>Social support: personal/professional/organisational, intra/interpersonal, society/community</p> <p>Social/group norms: subjective, descriptive, injunctive norms</p> <p>Learning and modelling</p>	
(10) Emotion	<p>Affect</p> <p>Stress</p> <p>Anticipated regret</p> <p>Fear</p> <p>Burn-out</p>	<p>Cognitive overload/tiredness</p> <p>Threat</p> <p>Positive/negative affect</p> <p>Anxiety/depression</p>	<p>Does doing x evoke an emotional response? If so, what?</p> <p>To what extent do emotional factors facilitate or hinder x?</p> <p>How does emotion affect x?</p>
(11) Behavioural regulation	<p>Goal/target setting</p> <p>Implementation intention</p> <p>Action planning</p> <p>Self-monitoring</p> <p>Goal priority</p>	<p>Generating alternatives</p> <p>Feedback</p> <p>Moderators of intention-behaviour gap</p> <p>Project management</p> <p>Barriers and facilitators</p>	<p>What preparatory steps are needed to do x? (prompt re individual and Implementation intention organisational)</p> <p>Are there procedures or ways of working that encourage x?</p>
(12) Nature of the behaviours	<p>Routine/automatic/habit</p> <p>Breaking habit</p> <p>Direct experience/past behaviour</p>	<p>Representation of tasks</p> <p>Stages of change model</p>	<p>What is the proposed behaviour (x)?</p> <p>Who needs to do what differently when, where, how, how often and with whom?</p> <p>How do they know whether the behaviour has happened?</p> <p>What do they currently do?</p> <p>Is this a new behaviour or an existing behaviour that needs to become a habit?</p> <p>Can the context be used to prompt the new behaviour? (prompts: layout, reminders, equipment)</p> <p>How long are changes going to take?</p>

		Are there systems for maintaining long term change?
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APPENDIX 2 MODEL SELECTION (CHAPTER TWO)

Model selection (Chapter Two)

Methods appropriate for analysing count data included Poisson regression, negative binomial (NB) regression which focuses on observed proportions, and zero-inflated Poisson (ZIP) and negative binomial (ZINB) which combines two models to handle over-dispersion (i.e., variance greater than the mean): one that focuses on the presence or absence of the outcome and a second that models the extent of the outcome when it is nonzero [1-3]. These regression models were conducted to assess the association between x-ray utilization rates for the year 2010 and explanatory variables with 95% confidence intervals (CIs). SAS GENMODE procedure with log link function, relative offset mode, and scaled Pearson chi-square statistic were selected for Poisson and binomial distributions. As the rate of incidence of the event (i.e. number of x-rays per patients at risk) was of interest instead of the number of occurrences, the model for the NB was as follows:

$$\log \lambda_i = \log (N) + \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \dots + \beta_k x_{ik} + \sigma \epsilon_i.$$

where λ_i is the expected value of the outcome variable y_i for subject i , N is the total number of patient at risk by provider, β_0 is the intercept, x_i are the independent variables with corresponding regression coefficients β_n , and $\sigma \epsilon_i$ is the disturbance or error term. To obtain a normal distribution of the dependent variable, all regression analyses were performed with the log-transformed using the relative offset mode. All coefficients have been put on an exponential scale. Thus, interpretation of the parameters (β) obtained from the NB regression models are in terms of incident rate ratios (IRR = $\exp[\beta]$). For the dummy variables (eg., Gender), the coefficients represent the change in predicted steps toward ordering x-rays from the category coded zero to

the category coded one [1]. Data for zero-inflated count were modeled using the SAS NLMIXED procedure.

Model selection

The likelihood ratio (LR) chi-square [4] and Cameron and Trivedi (1996) test [5] for over-dispersion compared Poisson and negative binomial models, while the Young's test (V statistic) was conducted in STATA® 12.0 (StataCorp, College Station, TX, USA) to compare the predicted probabilities of non-nested models (i.e., negative binomial versus zero-inflated negative binomial models) [6]. A non significant z-test ($V < 1.96$) indicates that the standard negative binomial model is preferred [4].

The data were rightly skewed with clumping at zero (i.e., over 70% of patients had no x-rays at 12 months (Figure 1a and 1b), and the variance was 18 to 22 times greater than the mean for both paid claims for spine x-rays (mean=3.35, variance=74.4), and claims paid within 5 days of initial visit (mean=2.5, variance=46.3). In this study of count data with evidence of over-dispersion, negative binomial regression with a more liberal assumption on variance was able to provide a better solution for both outcomes. Pearson Chi-Square were closer to 1, likelihood ratio test (LR) resulted in a small p -value, and values for BIC (Schwartz' Bayesian Information Criterion: $-2 \cdot \ln(L) + k \cdot \ln(n)$) were lower (Table 1). Further, the LR test, which follows Chi-square distribution with 1 degree of freedom, between 2 regressions was used to determine the preferred model for the data. The LR tests for each outcomes was $-2[18691.3 - (-11600.8)] = 6058.4$ and $-2[10456.7 - 21958.9] = 23004.4$, both of which are highly significant and indicate that Negative binomial regression is preferred over Poisson regression. In addition, the Alpha, the dispersion parameter, was greater than zero, and the null hypothesis was rejected for both outcomes (*spine x-ray per patients*: $\theta = 4.12$ (95% CI: 3.9-4.35),

$p < 0.0001$, and *immediate spine x-rays*: $\theta = 4.01$ (95% CI: 3.78-4.25), $p < 0.001$). Based on the Vuong test, standard negative binomial regressions compared to zero-inflated negative binomial model was a better fit for both outcomes ($V = 7.34$, $p > 0.16$ and $V = 9.33$, $p > 0.36$ for *spine x-ray claims per patient* and for *immediate spine x-rays* respectively).

Figure 1. Negative binomial distribution of the outcome measure: Spine x-rays ordered within 5 days of initial patient visit at 12 months.

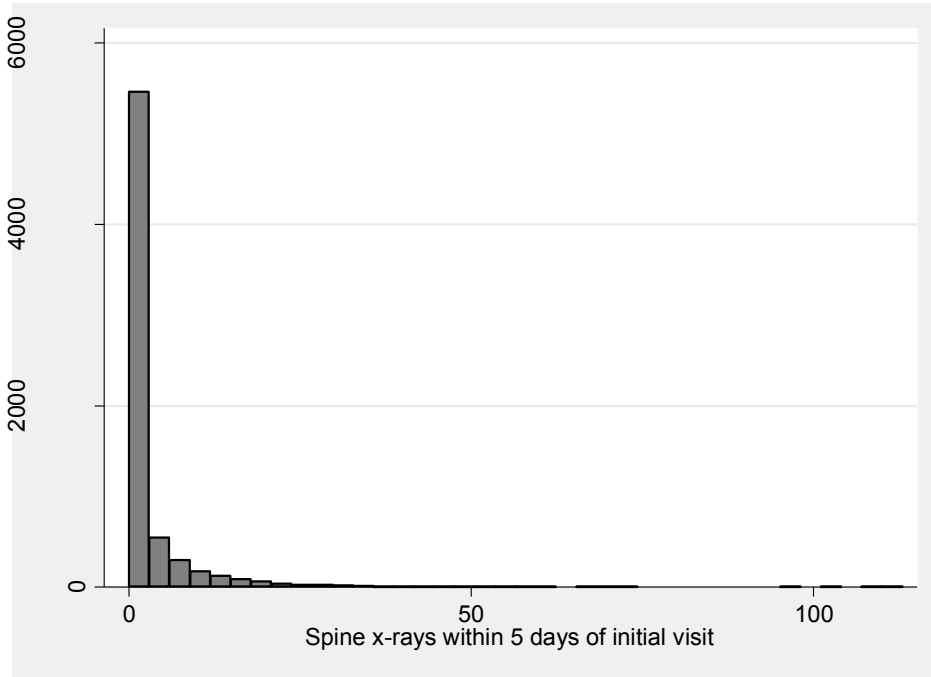
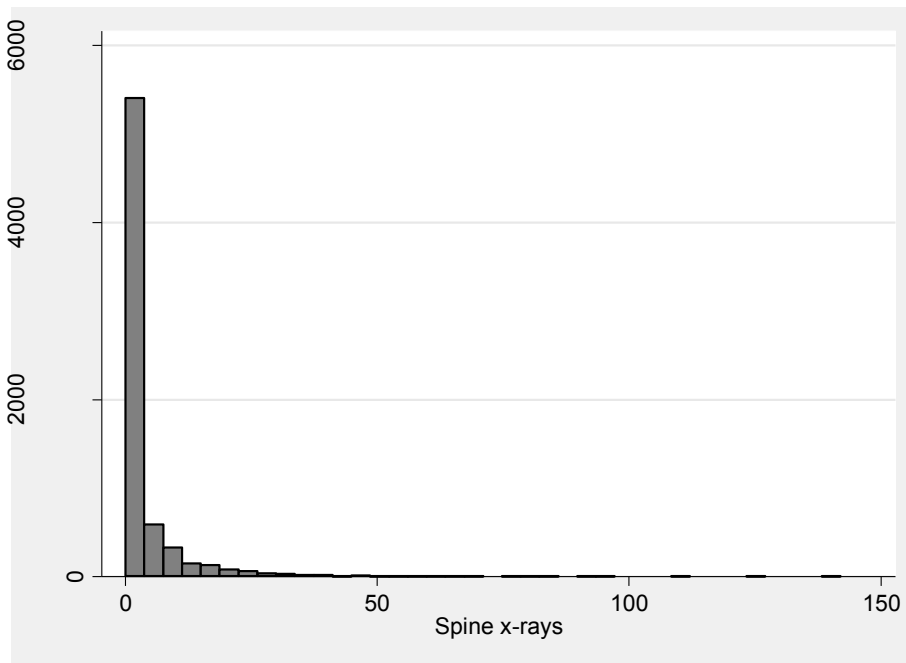


Figure 2. Negative binomial distribution of the outcome measure: Spine x-rays ordered by chiropractors at 12 months.



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Table 1. Criteria for assessing goodness of fit of negative binomial, Poisson, and zero-inflated negative binomial models for the two outcome measures.

	Spine rays per patients					Immediate spine x-rays				
Criterion	Negative binomial (df=6909)		Poisson (df=6909)		Zero-inflated negative binomial (df=6946)	Negative binomial (df=6912)		Poisson (df=6913)		Zero-inflated negative binomial (df=6946)
	Value	Value/DF	Value	Value/DF	Value	Value	Value/DF	Value	Value/DF	Value
Pearson Chi-Square	6246	0.9	64895	9.38		4483	0.66	44425	6.43	
Log Likelihood	34656		18961		18977	21958		10425		18973
BIC (smaller is better)	23307		55236		19150	19894		42890		19142
	Value	<i>t</i> statistic	Value	<i>t</i> statistic		Value	<i>t</i> statistic	Value	<i>t</i> statistic	
Alpha	4.12	3.36*				4.01	3.12*			
Vuong statistic					7.34					9.33

* $p < 0.001$.

We can see in our model that the dispersion parameter alpha is significantly different from zero. This suggests that our data is over-dispersed and that a negative binomial model is more appropriate than a Poisson model. The Vuong suggests that our zero-inflated model is not a significant improvement over a standard negative binomial model.

APPENDIX 3 SEGMENTED REGRESSION ANALYSIS (CHAPTER THREE)

Segmented regression analysis (Chapter Three)

An interrupted time series (ITS) analysis was undertaken from routinely collected data to determine whether dissemination of an imaging guidelines influenced care providers' spine x-ray ordering patterns. ITS designs collect multiple observations over time that are 'interrupted' by an intervention or treatment to determine whether an intervention has had an effect significantly greater than the underlying trend [1-3]. ITS design is the most robust method of measuring the effect of an intervention when randomized controlled trials are either not feasible, are impractical or when the intervention has already occurred like in this case [1, 3, 4]. ITS design allows for the statistical investigation of potential biases in the estimate of the effect of the intervention [1].

One of the greatest strength of segmented regression analysis is the intuitive graphical representation of results [5]. Visual inspection of the time series allows one to determine if the pattern has changed noticeably before and after the intervention (Figure 1).

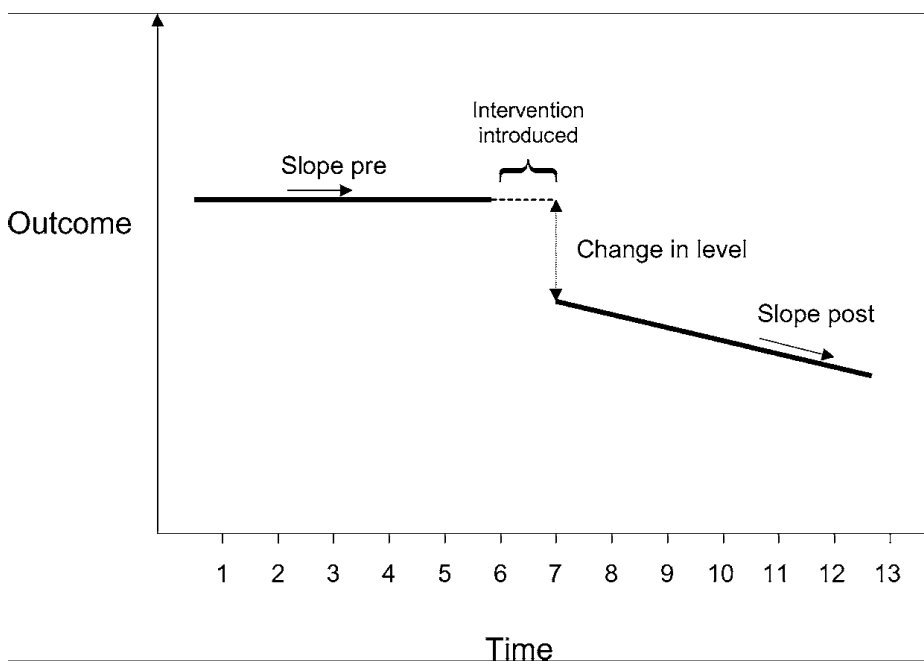


Figure 1. Graphic illustration of the effect sizes estimated by time series of an interrupted time series analysis. From Ramsay et al. *Technol Assessment Health Care* 2003;19:613–23.

We estimated changes in level and trend for the dissemination of the guidelines, and conducted sensitivity analyses on ASH QI initiatives.

As time is a predictor in segmented regression analysis, error terms of consecutive observations are often correlated (i.e., events closer together tend to be more similar than events further apart in time) [5]. Correcting for autocorrelation avoids underestimating standard errors and overestimated significance of the effects of an intervention. The Durbin-Watson (dw) statistic was utilized to test for autocorrelation. The dw statistic detected no evidence of auto-correlation (dw=1.95, p=0.99). Nonetheless, since time series data are typically auto-correlated, we undertook a conservative approach and utilized regression analysis with autoregressive errors.

To determine the expected mean number of the dependent variable following exposure to the intervention, three variables were entered into the time series model: a) a time variable; b) an indicator variable to differentiate between pre and post-guidelines publication period; and c) a post-intervention term. We specified the following linear regression model:

$$Y_t = \beta_0 + (\beta_1 * \text{Time}_t) + (\beta_2 * \text{Intervention}_t) + (\beta_3 * \text{Time}_t \text{ after Intervention}_t) + v_t \quad (1)$$

$$v_t = -\phi_1 v_{t-1} + \epsilon_t$$

$$\epsilon_t \sim N(0, \sigma^2)$$

Where Y_t is the response variable at time t (*mean number of spine x-ray within 5 days of initial visit per new patient exams*); time is a continuous variable indicating time in months at time t from the start of the observation period (1,2,3.....60); intervention is an indicator for time t occurring before (0=pre-intervention) or after (1=post-intervention) the guidelines, which were released at month 29 in the series; and time after intervention is a continuous variable counting the number of months after the intervention at time t , coded 0 before the guidelines and (time 29,30.....60) after the guidelines were released. In this model, the intercept β_0 estimates the baseline level of the outcome at time zero; β_1 estimates the change in outcome (*mean number of x-rays within 5 days of initial visit per new patient exams*) that occurs with each month before the intervention (i.e., the baseline trend); β_2 estimates the level change in the outcome

immediately after the intervention, that is, from the end of the preceding segment; and β_3 estimates the change in the trend in the outcome after the guidelines, compared with the monthly trend before the guidelines. The sum of β_1 and β_3 is the post-intervention slope. By using this model to estimate level and trend changes associated with the intervention, we control for baseline level and trend, a major strength of segmented regression analysis. The error term v_t represents the random variability not explained by the model. This autoregressive error structure $(-\phi_1 v_{t-1} + \varepsilon_t)$ with ε_t as white noise consists of a normally distributed random error and an error term at time t that may be correlated to errors at preceding or subsequent time points.

Sensitivity analysis

Estimating changes in level and trend for ASH quality improvement strategies

To control for changes in level and slope of the series that are caused by reasons other than the release of the diagnostic imaging guidelines, we conducted separate time series by adding the QI strategies as a change point in the segmented regression analysis of ITS, along with the primary intervention disseminated at month 29. The model with 2 points change was [5]:

$$Y_t = \beta_0 + (\beta_1 * \text{Time}_t) + (\beta_2 * \text{Intervention}_t) + (\beta_3 * \text{Time}_t \text{ after Intervention}_t) + (\beta_4 * \text{QI strategy}_t) + (\beta_5 * \text{Time}_t \text{ after QI strategy}_t) + v_t \text{ (error term)}$$

We first conducted a time series analysis adding the policy change implemented across ASH network at month 12. We performed a separate analysis using data for Georgia State only, adding the two ASH QI strategies, the policy change at month 12 and an educational intervention at month 21.

Results of segmented regression modelling can be reported as level and trend changes, or by comparing estimated post-intervention values of the outcome to values estimated at that time but based on baseline level and trend only, as if the intervention had not occurred (the counterfactual value) [5]. Intervention effect is expressed as the absolute difference between the predicted values of the outcome based on the intervention and the counterfactual value, or as the relative change, the ratio of the predicted to the counterfactual value, expressed as a percentage increase or decrease.

To estimate the guidelines dissemination (CPGs) effect across ASH network, the expected results from regression equation 1 at month 60, which is 32 months after the CPGs were disseminated, is expressed as:

$$\hat{Y}_{60(\text{with CPGs})} = \hat{\beta}_0 + \hat{\beta}_1 \times 60 + \hat{\beta}_2 \times 1 + \hat{\beta}_3 \times 32 \quad (2)$$

The following expresses regression 1 at 60 months had the guidelines not been disseminated (i.e., without any post-intervention effect in the model):

$$\hat{Y}_{60(\text{without CPGs})} = \hat{\beta}_0 + \hat{\beta}_1 \times 60 \quad (3)$$

The absolute intervention effect is the difference between equation 2 and 3:

$\hat{Y}_{60(\text{with CPGs})} - \hat{Y}_{60(\text{without CPGs})} = \hat{\beta}_2 + \hat{\beta}_3 \times 32$. The relative percent change in outcome associated with the CPGs is: $\hat{Y}_{60(\text{with CPGs})} - \hat{Y}_{60(\text{without CPGs})} / \hat{Y}_{60(\text{without CPGs})} \times 100$.

Results are expressed as mean \pm SD for continuous data and percentages and frequencies for categorical data.

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APPENDIX 4 FOCUS GROUPS (CHAPTER FOUR)

Summary list of potential barriers & enablers

Interview topic guide for focus groups

Elicited beliefs within TDF domains

Summary list of potential barriers and enablers

*General categories based on Cabana's framework**

1. Professional factors
1.1 Knowledge about the guidelines
○ lack of awareness
○ familiarity (volume of information, time needed to stay informed, critical reading skills)
1.2 Attitudes
○ lack of agreement with specific guidelines (interpretation of evidence, applicability to patients, lack of confidence in guidelines developer, perceived risk/benefits, costs)
○ lack of agreement with general guidelines (not applicable to practice population, biased synthesis, not practical, too cookbook, decrease autonomy, decrease doctors self-esteem)
○ outcome expectancy
○ perceived risks of liability
○ negative attitude toward Health Maintenance Organizations
○ reduces autonomy
○ professional dignity, wanting to do the right thing
○ wish to prevent referrals to another care provider
○ reasons evoked for taking spine radiographs
○ to rule out serious diseases/pathology/in the presence of red flags
○ to screen for contraindications prior to spinal manipulation
○ to identify the causative lesion(s) (misalignment/subluxation/dysfunction)
○ to determine the parameter for the adjustment (eg, line of drive) or to establish a treatment protocol (biomechanical and/or postural analysis)
○ if patient has filed a workers' compensation/automobile insurance claim
○ pressure from peers, patients and organizations
○ clinical uncertainty regarding patient presentation
○ professional autonomy (reaching clinical decisions without interference)
○ clinical ordering criteria, ease of test ordering
○ inertia of previous practice, past behaviour and prior use of guidelines
1.3 Characteristics
○ age
○ years in practice
○ chiropractic school attended
○ postgraduate diploma, educator
○ Practice setting
○ practice type (solo vs. group practice)
○ practice location (metropolitan vs. rural setting)
2. Patients characteristics

○ patient direct request
○ fear of serious disease
○ understanding of what the problem is and possible causes
○ beliefs about x-ray usefulness
○ satisfaction with care
○ guideline recommendations perceived to be offensive to patients
○ historical and physical findings (acute vs chronic, pain level & distress, co-morbidity),
3. Environmental characteristics (system/process and support/resource)
3.1 Health Maintenance Organization (HMO)
○ work structure, material contexts, work-related activities, relationships, work culture, type of management and policies
○ organizational constraints (time pressure, lack of resources, work pressure)
○ financial issues: cost to patient, to practice or lack of insurance coverage, inappropriate overall physician compensation or reimbursement, incentives for particular procedures
○ limited support/poor logistics for implementation, training opportunities and communication
3.2 Diagnostic services
○ Onsite radiography / self referral
○ limited access to radiology services (distance to imaging facility)
3.3 Guidelines themselves
○ ease of use
○ convenience
○ comprehensiveness , complexity
○ trialability (easy to tried out)
○ ease of implementing into practice, requires specific resources

* Cabana M, Rand C, Powe N, Wu A, Wilson M, Abboud P et al.. Why don't physicians follow clinical practice guidelines? A framework for improvement. JAMA 1999, 282:1458 - 1465.

Interview topic guide for focus groups

Diagnostic Imaging Guidelines Implementation Study

List of abbreviations

ASH: American Specialty Health Network

DIGASD: Diagnostic Imaging Guidelines for Adult Spine Disorders

HMO: Health Manage Organization

Red Flags: Indicators of serious pathology

RCT: Randomized Control Trial

I'd like to start by asking each one of you to state your name slowly for the benefit of the person who will be transcribing the interview. It would be useful if you could remember to say your first name before commenting during the early part of our discussion for the same reason.

We understand management strategies may vary somewhat depending on whether patients are within HMO's or not. Because we are interested in getting a wide range of information, we would appreciate if you could share your views for both ASH patients and non-HMO patients. This will make our findings more relevant to non HMO colleagues.

The behaviour of interest for today's discussion is « managing new patients with non-specific back and pain without taking spine x-rays ». I'm going to keep emphasizing this throughout the interview.

I would now like to ask you to tell me in general how you might manage a new patient with spine disorders in your office. By that I mean your usual routine once the patient is with you in the examining room, questions you ask and the exam procedures you do to determine if x-rays are needed.

- Prompts: What do you feel you do well? What do you feel you could do better?

Thank you.

Now for the rest of the interview, I have some slightly more specific questions. Some may seem repetitive, but please bear with me as the questions are derived from multiple theories on human behaviour and we are trying to identify which theory best applies in this area. I may also ask for clarification during the interview using probes such as:

'What do you mean'; 'Would you explain that'; 'What were you thinking at the time'; 'Take me through the experience'; 'What skills are required to do so?'; 'How and why do you use it?'

**** For the purpose of the interview, 'non-specific' refers to patients with uncomplicated mechanical back pain that varies with time and activity with no neurologic deficits, fractures or indicators of potentially serious pathologies (i.e. red flags)**

Nature of the behaviors

1. In your practice, how often do you come across new patients with non-specific back pain?
2. What percentage of those patients do you do spine x-ray on?
 - *prompts: do you systematically screen your patients for the presence of red flags?, do you assess the patient motivation of undergoing x-rays or no x-rays and if so, how?, What do you usually say to patients who ask to undergo x-rays but where you find it is not clinically warrant? Do you follow-up to monitor patients' progress after treating them without prior x-rays? What is the outcome usually?*

Skills

3. How easy or difficult is it to manage a new patient with non specific back pain without taking spine x-rays? Why?
 - *Prompts: patient's compliance, lack of training, complexity of cessation guideline, lack of counselling skills*
4. What skills are required to) manage a new patient with non-specific back pain without ordering spine x-ray?
 - *Prompt: how easy or difficult those skills are.*
5. How much expertise or experience do you think one needs to have to manage non-specific back pain in a new patient without taking spine x-ray ?
 - *prompt: history taking, physician exam*

Beliefs about capabilities

6. How confident are you that you can manage non-specific back pain in a new patient without taking spine x-rays despite any difficulty?

7. What problems/difficulties do you think you might encounter in managing non-specific back pain without any x-rays?
8. What could help you overcome these problems/difficulties?
 - *Prompts: additional training, communication techniques, continuing education, educational material, online information. Please elaborate on whether or not you think communication skills are important for managing patients without taking x-rays? Why is that?*

Motivation and goals

9. How important do you feel it is (i.e. priority) to manage a new patient with non-specific back pain without taking spine x-rays? (in relation to other tasks like history taking and examination or others)
10. How does this differ between HMO and non-HMO patients?
 - *Prompts: Are there any incentives that motivate you to manage patients with non-specific back pain without taking any x-rays? - recommendations from ASH, from Regulatory body, colleagues, the medical community or patients themselves*
11. Would there be anything else that you want to do or achieve that might interfere with your practice with regard to managing a new patient with non-specific back pain without taking spine x-rays?
12. Are there any incentives that motivate you to manage a patient with non-specific back pain without taking spine x-rays?
 - *Prompt: goals within yourself? external?*
13. Do you set goals for yourself or your practice with regard to managing a new patient with non-specific back pain without taking spine x-rays?
 - *Prompt: goals within yourself? external?*

Beliefs about consequences

14. What are the benefits of managing a new patient with non-specific back pain without taking spine x-rays?
 - *Prompt: to self, or to patients i.e. reducing ionizing radiation exposure & costs?, profession, healthcare organization*
15. Do you feel there are potential harms or disadvantages in managing patients with non-specific back pain without any x-rays?
 - *Prompts: 1) screening to prevent rare possible complications associated with spinal manipulative therapy, 2) accurate prognosis; 3) patient preference and satisfaction; medico legal concerns or political influence & administrative factors*
16. Do you feel that the benefits of managing a new patient with non-specific back injury without taking spine x-rays outweigh the costs? Why or why not?
17. Is there any incentive/disincentive that you can think of that influence whether or not you manage a new patient with non-specific back pain without taking spine x-rays?

Environmental context and resources

18. What aspects of your environment (physical vs. resource factors) influence whether or not you are able to order spine x-rays for patients with non-specific back pain?

- *Prompt: resources available to help you manage non-specific back pain patients without taking x-rays (information pamphlet or posters to inform patients about potential risks of ionizing radiation exposure)?*

19. Do you think having onsite radiology equipment influence the decision to x-ray new patients with non-specific back pain?

Social influences

20. How might views/opinions of others (colleagues, patients, professional groups) influences your decision to x-ray patients with non-specific back pain?

- *Prompt: anyone else; in what circumstances*

21. Do organizations such as HMO's influence whether or not you order x-rays for new patient with non-specific back pain without taking spine x-rays?

Emotion

22. Do patient emotions/apparent distress ever affect whether or not you order spine x-rays for patients with non-specific back pain?

23. Does managing patient with non-specific back pain without taking spine x-rays evoke an emotional response in you?

- *Prompt: Do your own emotions ever affect your decision to manage patients with non-specific back pain without taking spine x-rays?*
- *Prompts: fear of missing a significant pathology*

Knowledge

We have talked about some of the evidence; I'd also like to find out about your knowledge and use of guidelines:

24. Do you use any guideline to help you make informed decision about when to x-rays for patients with back pain?

- *Prompts: How do you use it? Why do you use it? What do you think of it?*

25. How do you use the guidelines? (i.e. what do you actually, physically do? Do you ever read the guidelines to check if a behaviour you performed was guideline-compliant?)

26. What other evidence are you aware of?

27. How well do you think you understand the evidence surrounding optimal use of x-rays for non-specific pain?

28. What are your thoughts about the recommendations proposed by the DIGASD?

- *Prompts: Do you believe it to be evidence-based? how did you use it? When did you use it? What do you think of it?*

29. Do you agree with the guidelines? i.e. are the guidelines representatives of the evidence (quality, appropriateness)?

30. What kind of additional information would most likely influence your changing your clinical management?

- *Prompts: RCT's, Systematic reviews, discussion with colleagues, conferences/seminars*

Memory, attention and decision processes

31. What thought process might guide your decision to manage a new patient with non-specific back pain without taking spine x-rays?
 - *Prompt: What goes through your mind?*
 - *Prompt: Is this something you would have to think a lot?*
32. Is managing patients with non-specific back pain without taking spine x-rays something you would usually do?
33. In what situation, if any, might it be difficult to think of an alternative to using x-rays?
34. What rules of thumb do you use to reach a decision, if any?
 - *Prompts: red flags, decision rules, guidelines...*

Social/professional role and identity

35. Do you think it is an appropriate part of your job to manage new patients with non-specific back pain without taking spine x-rays?
 - *Prompts: What are they and why? Do your colleagues generally agree with you on this issue?*
36. Do you sometimes feel constrained by guidelines? What about protocols?
37. Is there anything else about your professional role that influences you managing patients without referring for spine x-ray? (i.e. Consensus in the chiropractic profession)
38. Do you tend to practice using an x-ray driven techniques to establish a treatment protocol?
i.e. Upper cervical or rehabilitation techniques (biomechanical analysis)
 - *Prompts: What are they and why?*

Behavioural regulation

39. If you're thinking about changing your own practice to manage new patients with non-specific back pain without taking spine x-rays, how would you do it?
 - *prompt: self change, practice level change, training, education*
40. What might you do In order to reduce the likelihood of needing spine x-rays?
41. Are there procedures or ways of working that might encourage you to manage a new patient with non-specific back pain without taking spine x-ray?
42. If you decide to manage with non-specific back pain without taking spine x-rays, how confident are you that your associates can carry this out?
43. The evidence from research suggests that x-rays are not useful for non specific back pain pain. With that in mind, in terms of using less spine x-rays:
 - *What might need to be done differently?*
 - *What would you do differently?*
 - *Who needs to do what differently, when, where, how, how often and with whom?*

That's all the questions I had for you today. Has anything else occurred to you about this topic that we haven't asked about?

Overall, what were your thoughts about the interview?

Elicited beliefs within TDF domains

TDF domains	Specific beliefs
<i>Nature of the behaviours</i>	<ol style="list-style-type: none"> 1. I avoid ordering x-rays unless the history reveals specific indicators of a serious condition 2. I use x-rays as a diagnostic tool (to rule-out pathologies, fractures or dislocation) or when patients fail to improve 3. I rarely order x-rays 4. 5-10% of my new patients are x-rayed. I tend to be fairly conservative on x-ray 5. 40-50% of my new patients with back pain are x-rayed 6. 50-80% of my new patients with non-specific back and are x-rayed 7. I routinely x-ray my new patients with non-specific back and are x-rayed
<i>Skills</i>	None identified
<i>Beliefs about capabilities</i>	<ol style="list-style-type: none"> 1. I'm confident that I can manage non-specific back pain without x-rays 2. I'm comfortable/uncomfortable I can manage non-specific back pain without x-rays 3. For appropriate patient management, I prefer to x-ray when I'm uncertain of the diagnosis 4. As a result of my experience, managing new patients with non specific back pain without taking spine x-rays is easy/harder 5. Workers' Compensation patients already have x-rays before seeing me
<i>Motivation and goals</i>	<ol style="list-style-type: none"> 1. Patient centered care is important to me 2. Finding out the reasons why a patient wants to have x-rays done when I think they don't need it helps me better communicate with them. 3. I only order x-rays when I feel they are clinically indicated 4. Reduce patient radiation exposure is important to me 5. I'm motivated to adapt my practice based on new evidence 6. Ordering x-rays is important/not important to me
<i>Beliefs about consequences</i>	<ol style="list-style-type: none"> 1. I take x-rays to avoid risks of adverse effects for my patient 2. I take x-rays so I'm not responsible for causing adverse treatment effects (practitioner consequence) 3. I order/I don't order x-rays because of the risk of litigation 4. I take follow-up x-rays to help monitor patient conditions / I don't think follow-up x-rays are useful 5. Patients may/may not benefit from seeing their own x-rays to improve treatment compliance 6. When I can, I avoid repeating x-rays because of ionizing radiation exposure 7. Benefits of managing non-specific back pain without x-rays include: minimizing ionizing radiation exposure, reducing costs, minimizing adverse events from further investigation, avoiding labelling of patients, maintaining the highest Tier 8. HMO will restrict your autonomy if you don't conform to their standards 9. X-rays are/are not helpful for making a diagnosis in uncomplicated back pain 10. I agree/disagree with ordering routine spine x-rays 11. X-rays are low-costs and low risk procedures 12. Disadvantages in managing patients with non-specific back pain without any x-rays include: risk of missing a pathology or anomalies such as spondylolisthesis 13. Guidelines parameters should be respected 14. Guidelines are designed to further restrict practice 15. Restrict x-ray use for cost reduction by HMO may impact on the quality of care
<i>Environmental</i>	<ol style="list-style-type: none"> 1. Onsite imaging does/does not increase x-ray utilization rate for regular chiropractic patients 2. Not having onsite imaging may/may not: influence patient decision to consult, decrease patient compliance and delays care

<i>context & resources</i>	3. I do/don't have signs informing of the risk of radiation exposure
<i>Social influences</i>	<ol style="list-style-type: none"> 1. Patient expectation may/may not influence my decision to order x-rays 2. Colleagues, opinion leaders, mentors or instructors do/do not influence my practice 3. My training did/did not influenced my x-ray utilisation rate 4. Patient emotion can influence whether or not I order x-rays 5. HMO's/institutions guidelines, protocols or requirements do/do not influence my decision to order x-rays 6. The literature I read influence my imaging practice
<i>Emotion</i>	<ol style="list-style-type: none"> 1. X-ray guidelines are a source of anxiety for providers as we need to conform with the HMO 2. I get worried when patients don't improve as expected, so I order x-rays
<i>Knowledge</i>	<ol style="list-style-type: none"> 1. I am/am not aware of x-ray guidelines for chiropractors 2. There are conflicting guidelines 3. I agree/disagree with the guidelines 4. The guidelines are the minimum standard to follow 5. There is/is not enough evidence to support the guidelines 6. The evidence upon which the guidelines are based is not clear
<i>Memory, attention, decision processes</i>	<ol style="list-style-type: none"> 1. The decision to order or not order x-rays is based on the patient history and the patient age 2. The decision to order or not order x-rays is based on the patient history and examination 3. The decision to order x-rays is based on the patient history, examination and my experience 4. The decision to order x-rays is based on my experience alone 5. High pain intensity and inability to examine the patient are indicators of the need for x-rays 6. I order x-rays if patients are not improving after 6-8 visits or 3-4 weeks of care 7. I take x-rays if results are likely to changes my treatment protocol 8. Experience has reduced the effort required for me to make the decision
<i>Social/professional role & identity</i>	<ol style="list-style-type: none"> 1. X-ray driven chiropractic treatments are/are not part of my practice 2. The schools I attended did/did not train me to take routine x-rays 3. Staying current is important for the profession's credibility 4. Appropriate ordering of x-rays may/may not improve the credibility of the chiropractic profession 5. My practice is/is not dictated by ASH Guidelines 6. I have/I don't have the autonomy 7. Chiropractors pick and choose the guidelines to best suit their practice 8. The guidelines mostly apply to those chiropractors with x-ray ordering behaviour at the extreme ends 9. Lack of standardization, insufficient knowledge and skills in the profession are problematic 10. Abuse exists in any profession 11. Routine x-rays is/is not acceptable in our profession 12. The Guidelines do/do not support my way of practice
<i>Behavioural regulation</i>	<ol style="list-style-type: none"> 1. Audit and Feedback may help improve individual behaviour 2. Having access to a mentor or an experienced clinician is a way to encourage best practice 3. Guidelines implementation should include long term strategies for sustainability 4. Introducing the guidelines and discussing risk/benefits during CME may help reduce x-ray utilisation rate 5. Patient decision tools may help reduce x-ray utilisation 6. Guidelines should be targeted at those who either never use x-rays or routinely use x-rays 7. Guidelines should be based on high level evidence 8. Guidelines should be objective and not biased 9. Guidelines adherence may improve if they are simplified, have key messages, are freely accessible

	<p>and are presented as valuable tools for short-term care</p> <ol style="list-style-type: none">10. Regulatory body may effective to reduce overuse of x-rays11. Practice changes would have to be instituted by the schools as they're the ones setting standards of care regarding x-ray ordering12. Sharing liability would help me adhere to guidelines recommendations
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APPENDIX 5 SURVEY QUESTIONNAIRE AND QUESTIONNAIRE INDEX (CHAPTER FIVE)

CONFIDENTIAL

Individual factors influencing utilization of spine x-rays

THANK YOU VERY MUCH FOR TAKING THE TIME TO PARTICIPATE.

The purpose of this questionnaire is to better understand chiropractors' views on utilization of spine x-rays in otherwise healthy patients. We are particularly interested in the role of lumbar spine x-rays for the management of low back pain.

We would like you to think about how you might...

manage a patient with uncomplicated back pain without spine x-rays

For the purpose of this questionnaire we want you to consider the role of lumbar spine x-rays for the management of cases such as the following scenarios while answering all questions.

- A 23 year-old woman with acute low back pain for a week;
- A 28-year-old auto mechanic with sudden onset of back pain;
- A 35-year-old architect with occasional low back discomfort for 2 years;
- A 49-year-old administrative assistant with a 6 week history of low back and leg pain;
- A 41 year old self-employed carpenter with recurrent low back pain.

In this questionnaire, '**uncomplicated back pain**' refers to adult patients (age 18-65) with back symptoms of short to long term duration but with no recent acute trauma, no progressive neurological deficits, and no alerting features of serious conditions (red flags) such as tumors, infections or fractures.



This questionnaire should take no more than 35 minutes to complete. Some questions may seem quite similar, but they are different and it is important that you answer them all. Please read each question carefully and answer it to the best of your ability. There are no correct or incorrect responses; we are interested in your point of view.

SECTION 1:

Please circle the response that best represents your opinion about each statement below.

Question 1. From memory, for approximately how many of your **last 10** patients who presented with uncomplicated back pain **as a new patient** did you manage without lumbar x-rays? (0 –10) *OLT - self-reported past behaviour*

0 1 2 3 4 5 6 7 8 9 10

	Strongly disagree			Strongly agree			
Question 2.							
a. I am confident that I can <i>manage patients with uncomplicated back pain without lumbar x-rays. TPB - PBC (direct)</i>	1	2	3	4	5	6	7
b. I have a clearly formulated plan in mind of the necessary sequence of steps required to <i>manage patients with uncomplicated back pain without lumbar x-rays. Action planning</i>	1	2	3	4	5	6	7
c. It is my usual practice to take lumbar x-rays of patients with uncomplicated back pain <i>OLT - evidence of habit</i>	1	2	3	4	5	6	7

Question 3. In the next 3 months, the following individuals or organizations would **disapprove/approve** if I was to *manage patients with uncomplicated back pain without lumbar x-rays TIB - Normative beliefs*

	Strongly disapprove			Strongly approve			
a. My colleagues	1	2	3	4	5	6	7
b. My patients	1	2	3	4	5	6	7
c. Post graduate course instructors or published literature	1	2	3	4	5	6	7
d. My national association or licensing body	1	2	3	4	5	6	7
e. Developers of guidelines, best practice documents or protocols	1	2	3	4	5	6	7

	Strongly disagree			Strongly agree			
Question 4.							
a. I have a readily accessible plan for under what clinical circumstances I will <i>manage patients with uncomplicated back pain without lumbar x-rays. Action planning</i>	1	2	3	4	5	6	7
b. If I <i>manage patients with uncomplicated back pain without lumbar x-rays</i> , it is highly likely that the patient will be worse off overall. <i>OLT- anticipated consequence</i>	1	2	3	4	5	6	7
c. My personal values lead me to <i>manage patients with uncomplicated back pain without lumbar x-rays. Moral norm</i>	1	2	3	4	5	6	7

Question 5. In the next 3 months...

Strongly disagree

Strongly agree

- | | | | | | | | |
|--|---|---|---|---|---|---|---|
| a. When I see a patient with uncomplicated back pain, I automatically consider taking lumbar x-rays regardless of the history or exam findings. <i>OLT - evidence of habit</i> | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| b. I can overcome all obstacles, whatever they may be, to <i>managing patients with uncomplicated back pain without lumbar x-rays</i> . <i>TPB - PBC (direct)</i> | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| c. I intend to <i>manage patients with uncomplicated back pain without lumbar x-rays</i> . <i>TPB intention</i> | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

Question 6.

Strongly disagree

Strongly agree

- | | | | | | | | |
|--|---|---|---|---|---|---|---|
| a. I am expected to <i>manage patients with uncomplicated back pain without lumbar x-rays</i> . <i>TPB - subjective norms (direct)</i> | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| b. If I <i>manage patients with uncomplicated back pain without lumbar x-rays</i> , the consequences for me as a chiropractor (e.g. stress, time, future consultation) will be worse in the long run. <i>OLT - anticipated consequence</i> | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

Question 7. In the next 3 months, how likely are you to manage patients with uncomplicated back pain without spine x-rays when... *TPB - PBC (strength of control belief)*

Very Unlikely

Very Likely

- | | | | | | | | |
|--|---|---|---|---|---|---|---|
| a. The patient frequently misses appointments (no-show). | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| b. Policies from insurance companies or HMOs dictate x-ray protocol. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| c. The patient is disinterested/not responsive to advice. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| d. You feel rushed when your evaluating a new patient in the consultation. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

Question 8. In my clinic, when patients present with uncomplicated back pain, managing them without lumbar x-rays is something... *Habit - SRHI*

Strongly disagree

Strongly agree

- | | | | | | | | |
|---|---|---|---|---|---|---|---|
| a. I do frequently. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| b. I do automatically. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| c. I do without having to consciously remember. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| d. that makes me uncomfortable if I do it. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| e. I do without thinking. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| f. that would require effort to do. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| g. that belongs in my routine. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| h. I start doing before I realize I'm doing it. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| i. I would find hard to do. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| j. I have no need to think about doing. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| k. that is typical for me. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| l. I have been doing for a long time. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

Question 9. In the next 3 months...

Strongly disagree

Strongly agree

- | | | | | | | | |
|---|---|---|---|---|---|---|---|
| a. Managing <i>patients with uncomplicated back pain without lumbar x-rays</i> is compatible with most styles of practice. <i>TIB - self identity</i> | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| b. Most people whose opinion I value would approve if I <i>manage patients with uncomplicated back pain without lumbar x-rays</i> . <i>TPB - subjective norm direct</i> | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

c. I plan to *manage patients with uncomplicated back pain without lumbar x-rays*. *TPB - intention* 1 2 3 4 5 6 7

Question 10.

	Strongly disagree							Strongly agree
a. It is in accordance with my own personal principles to <i>manage patients with uncomplicated back pain without lumbar x-rays</i> . <i>Moral norm</i>	1	2	3	4	5	6	7	
b. I have a clearly formulated plan in mind for how I will <i>manage patients with uncomplicated back pain without lumbar x-rays</i> . <i>Action planning</i>	1	2	3	4	5	6	7	
c. I consider that <i>managing patients with uncomplicated back pain without lumbar x-rays</i> is appropriate for a chiropractor in my region. <i>TIB - role beliefs</i>	1	2	3	4	5	6	7	

Question 11. Thinking about your **next** 10 new patients presenting with uncomplicated back pain, how many do you expect to refer for, or take, a lumbar x-ray? (Please circle a number from 0 to 10) *Behaviour intention (performance)*

0 1 2 3 4 5 6 7 8 9 10

Question 12. In the next 3 months...

For me, managing patients with uncomplicated back pain without lumbar x-rays would be:

TPB - attitude direct (instrumental and experiential items); Also TIB - affect

Not at all Beneficial	1	2	3	4	5	6	7	Very Beneficial
Very Harmful	1	2	3	4	5	6	7	Not at all Harmful
Bad Practice	1	2	3	4	5	6	7	Good Practice
Very Unsatisfying	1	2	3	4	5	6	7	Very Satisfying
Risky for Liability	1	2	3	4	5	6	7	Safe for Liability
Very Frustrating	1	2	3	4	5	6	7	Not at all Frustrating

Question 13. For me, managing patients with uncomplicated back pain without lumbar x-rays would... *TPB - attitude (behavioural beliefs); Also TIB - perceived consequences*

	Very Unlikely							Very Likely						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
a. Reassure the patient.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
b. Be a good way to introduce patients to chiropractic.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
c. Contribute to saving health care cost.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
d. Increase the risk of missing an underlying pathology.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
e. Contribute to reducing unnecessary radiation exposure to patients.	1	2	3	4	5	6	7	1	2	3	4	5	6	7

Question 14. To what extent do the following elements influence (impact) managing patients with uncomplicated back pain without lumbar x-rays in your practice: *TIB - facilitating conditions (external: a-f; internal: g,h)*

	A very little extent							A very great extent						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
a. Minimizing malpractice risk	1	2	3	4	5	6	7	1	2	3	4	5	6	7
b. Having onsite imaging	1	2	3	4	5	6	7	1	2	3	4	5	6	7
c. No costs to patients / health system	1	2	3	4	5	6	7	1	2	3	4	5	6	7
d. Clinical complexity	1	2	3	4	5	6	7	1	2	3	4	5	6	7
e. Formal training (i.e. chiropractic college attended, post-graduate training)	1	2	3	4	5	6	7	1	2	3	4	5	6	7
f. Remuneration	1	2	3	4	5	6	7	1	2	3	4	5	6	7
g. Philosophical beliefs	1	2	3	4	5	6	7	1	2	3	4	5	6	7
h. Use of particular chiropractic techniques	1	2	3	4	5	6	7	1	2	3	4	5	6	7

Question 15. I find it DIFFICULT to manage patients with uncomplicated back pain without lumbar x-rays IF: *(a-d) PBC (perceived power)*

	Strongly disagree							Strongly agree						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
a. The patient frequently misses appointments (no-show).	1	2	3	4	5	6	7	1	2	3	4	5	6	7
b. Policies from insurance companies or Healthcare Management Organizations (HMOs) dictate x-ray protocol.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
c. The patient is not responsive to advice.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
d. When I am evaluating a new patient in the consultation I feel rushed.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
e. I consider that managing <i>patients with uncomplicated back pain without lumbar x-rays</i> is appropriate for a chiropractor with my clinical skills <i>TIB - role beliefs</i>	1	2	3	4	5	6	7	1	2	3	4	5	6	7

Question 16. In the next 3 months...

	Strongly disagree							Strongly agree						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
a. I will try to <i>manage patients with uncomplicated back pain without lumbar x-rays</i> . <i>TPB - intention (direct)</i>	1	2	3	4	5	6	7	1	2	3	4	5	6	7
b. I feel under social pressure to <i>manage patients with uncomplicated back pain without lumbar x-rays</i> . <i>TPB - subjective norm (direct)</i>	1	2	3	4	5	6	7	1	2	3	4	5	6	7
c. It is entirely up to me whether or not I <i>manage patients with uncomplicated back pain without lumbar x-rays</i> . <i>TPB - PBC (direct)</i>	1	2	3	4	5	6	7	1	2	3	4	5	6	7

Question 17.	Strongly disagree							Strongly agree
a. It would be acting as a responsible person for me to <i>manage patients with uncomplicated back pain without lumbar x-rays</i> . <i>Moral norm</i>	1	2	3	4	5	6	7	
b. I am concerned about the quality of patient care <i>TIB – self identity</i>	1	2	3	4	5	6	7	
c. It is within my principles to manage patients with uncomplicated back pain without lumbar x-rays in my practice <i>TIB - personal norms</i>	1	2	3	4	5	6	7	
d. I consider my style of practice mainstream <i>TIB – self identity</i>	1	2	3	4	5	6	7	

Question 18. I feel under pressure when: <i>TPB - subjective norms (indirect)</i>	Not at all							Very much
a. My patients expect me to <i>manage patients with uncomplicated back pain without lumbar x-rays</i>	1	2	3	4	5	6	7	
b. My malpractice insurer expect me to <i>manage patients with uncomplicated back pain without lumbar x-rays</i>	1	2	3	4	5	6	7	
c. Published guidelines, best practice documents, organizational protocols or procedures strongly support <i>managing patients with uncomplicated back pain without lumbar x-rays</i>	1	2	3	4	5	6	7	

Question 19.	Strongly disagree							Strongly agree
a. I consider that it is normal for a chiropractor to <i>manage patients with uncomplicated back pain without lumbar x-rays</i> . <i>TIB – professional norm</i>	1	2	3	4	5	6	7	
b. I have readily available alternative strategies regarding what to do when challenges disrupt my initial plan to <i>manage patients with uncomplicated back pain without lumbar x-rays</i> . <i>Coping planning</i>	1	2	3	4	5	6	7	
c. I consider that it is appropriate for a chiropractor working within a network to <i>manage patients with uncomplicated back pain without lumbar x-rays</i> . <i>TIB - professional norm</i>	1	2	3	4	5	6	7	

Question 20. In general, how important do you consider these factors to be? <i>TPB - attitude (outcome evaluation)</i>	Unimportant							Important
a. Reassuring patient	1	2	3	4	5	6	7	
b. Introducing patients to chiropractic	1	2	3	4	5	6	7	
c. Saving health care cost	1	2	3	4	5	6	7	
d. Missing an underlying pathology	1	2	3	4	5	6	7	
e. Reducing unnecessary radiation exposure to patients	1	2	3	4	5	6	7	

Question 21.	Strongly disagree							Strongly agree
a. I consider that managing <i>patients with uncomplicated back pain without lumbar x-rays</i> is appropriate for a chiropractor with my years of experience <i>TIB - role beliefs</i>	1	2	3	4	5	6	7	
If I <i>manage patients with uncomplicated back pain without lumbar x-rays</i> , my life as a chiropractor will be easier overall. <i>OLT – anticipated consequences</i>	1	2	3	4	5	6	7	
c. It is my responsibility to order lumbar x-rays of patients with uncomplicated back pain prior to undertaking manual therapy. <i>TIB - personal norm</i>	1	2	3	4	5	6	7	
d. Managing <i>patients with uncomplicated back pain without lumbar x-rays</i> is a proof of a chiropractor’s competence <i>TIB - self identity</i>	1	2	3	4	5	6	7	

Question 22.	Strongly disagree							Strongly agree
a. I have developed alternative strategies regarding what to do when a patient insists on having lumbar x-rays that I think are unnecessary <i>Coping planning</i>	1	2	3	4	5	6	7	
b. A chiropractor who manages <i>patients with uncomplicated back pain without lumbar x-rays</i> is concerned about the quality of patient care <i>TIB - self identity</i>	1	2	3	4	5	6	7	
c. I consider that it is appropriate for a chiropractor working in a private clinic to manage <i>patients with uncomplicated back pain without lumbar x-rays</i> . <i>TIB - professional norm</i>	1	2	3	4	5	6	7	

Question 23.	Strongly disagree							Strongly agree
a. I would feel guilty if I was managing <i>patients with uncomplicated back pain without lumbar x-rays</i> . <i>TIB - personal norm</i>	1	2	3	4	5	6	7	
b. I have developed alternative strategies regarding what to do when insurance companies want lumbar x-rays that I think are unnecessary. <i>Coping planning</i>	1	2	3	4	5	6	7	
c. I consider myself competent <i>TIB – self identity</i>	1	2	3	4	5	6	7	

Question 24. How important is it to you to do: <i>TPB - subjective norm (motivation to comply)</i>	Not Very important					Very Important	
a. what patients think you should?	1	2	3	4	5	6	7
b. what malpractice insurer say you should?	1	2	3	4	5	6	7
c. what published guidelines, best practice documents, organizational protocols or procedures say you should?	1	2	3	4	5	6	7

****PLEASE PROCEED TO SECTION 2****

SECTION 2:

The following scenarios include various elements that may influence your decision to manage adult low back pain patients with or without lumbar spine x-rays. We appreciate that the scenario format means that skills you may normally draw on (e.g. non-verbal aspects) cannot be a factor in your assessment. Nevertheless, we ask you to address each scenario and make a decision as to whether you would or would not order lumbar spine x-rays. We have left a space at the end of this questionnaire for you to comment on any aspect of a scenario, or your decision, if you so choose.

Case 1. A 23 year-old woman has suffered from acute low back pain for a week. She has been unable to do her job managing a hospital cafeteria at this time. While anxious to return to work, she feels immobilized by the pain. There is no history of trauma. The pain is limited to the low back area, without radiation. On physical examination, there is marked limitation of forward flexion and tenderness in the left paraspinal region. The neurological examination is normal with straight leg raising to 90 degrees. Only medication used are oral contraceptives.

Question 25. Your decision: Refer for x-ray? Yes No

Case 2. A 28-year-old auto mechanic with no prior history of back trouble reports that he experienced sudden onset of back pain while bending sideways as he was picking up a tire yesterday morning. Bed rest slightly improved his pain and he returned to work today. However, his back pain progressively increased throughout the day, and by the afternoon he was unable to bend and had to leave work. He denies any radiation of back pain down to either leg and his past medical history is unremarkable. Physical examination reveals markedly limited forward and right and left lateral flexion, as well as paraspinal muscle spasm and tenderness, but no loss of lumbar lordosis. Both straight leg raise (SLR) and Patrick's tests are negative. Neurological examination, including motor power, sensory, and reflex tests are normal.

Question 26. Your decision: Refer for x-ray? Yes No

Case 3. A 35-year-old architect has had occasional low back discomfort over the last 2 years but has not sought professional advice. One week ago, he felt excruciating left leg radiation after pushing a heavy object at work that caused him to miss 3 days from work. After returning to work he experienced sharp pain in his lower back area with tingling and numbness in his left thigh, posterior calf, and lateral aspect of his left foot, made worse by prolonged standing and forward bending. He denies any bowel or bladder dysfunction. Past medical history is unremarkable. Physical examination reveals decreased pinprick sensation over the posterior aspect of the left calf and lateral foot, a diminished left ankle reflex, but no leg weakness. Both SLR on the left and cross-over SLR tests are positive and limited to 45 degrees. Patrick's test is negative.

Question 27. Your decision: Refer for x-ray? Yes No

Case 4. A 49-year-old administrative assistant presents with a 6 week history of low back pain with referral to the right buttock. The pain initially came on gradually over 48 hours. Since the onset of the pain she has been unable to work and has been taking Ibuprofen regularly. She also has had moderate level of disability and particularly has difficulty

rising from a chair and can stand and walk only for short periods. There is no history of trauma. Her work consists mainly of computer work with some standing. She feels she has to move slowly and needs to lie down to rest more often than usual. She demonstrates some anxiety and has felt tired and worn out most of the time since the pain started. Her average pain over the last two weeks has been 4 out of a maximum of 10. Her general health is good. On physical examination, there is marked limitation of forward flexion and right paraspinal tenderness. Neurological examination is normal. Past medical history and physical examination findings are unremarkable, except for 2 previous episodes of LBP in the past 3 years

Question 28. Your decision: Refer for x-ray? Yes No

Case 5. A recently divorced 41 year old self-employed carpenter has consulted you on four occasions with low back pain that is not improving after two weeks. His work and normal activities have been significantly reduced since the onset of the pain, however he cannot afford to take time off work (own business; no coverage). While he recalls no specific incident, the pain intensity varies throughout the day, mostly 6-7 out of 10. He feels better when lying on his back with knees bent or when applying heat. Bending, standing for prolonged periods or squatting aggravate his back pain. There are no leg radiation, no associated symptoms and past health history is unremarkable. He has experienced previous episodes of low back pain but never underwent any form of spine imaging. He is frustrated with the lack of improvement and thinks that further investigation is required to “find out what is wrong” with his back.

Question 29. Your decision: Refer for x-ray? Yes No

****P

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PROCEED TO SECTION 3****

Section 3. Demographic information

a. Approximately how many years have you _____ years
been practicing?

b. How many chiropractors (excluding you) _____
are there in your practice?

c. Describe the population PRIMARILY served by you in your practice (Please check only one).
 Urban
 Suburban
 Rural
 Geographically isolated/remote
 Other (Please specify) _____

d. The following is a list of office type. Please specify which of the settings is your MAIN **patient care** setting (i.e., the setting where you spend most of the time providing patient care).
 Professional/medical health care building
 Chiropractic college
 Office building
 Free standing clinic
 Home
 Other (Please specify) _____

e. Do you have onsite imaging services? Yes No

f. On average, how many patient contact hours do you have per week?
 Full time (over 25 hours/wk);
 Part time (between 1-24 hours/wk)

g. Which chiropractic school did you graduate from? _____

h. In which province is your practice located? _____

i. Gender: Male Female

j. Age: _____ years

****THANK YOU FOR COMPLETING THE QUESTIONNAIRE****

Honorarium

You have now completed the entire questionnaire – thank you once again! Once we receive your completed questionnaire, your name will be entered for a draw to win one of ten \$250 gift cards from Amazon.

Do you have any additional comments? Please feel free to comment on any aspect of the survey here.

If you wish to find out more about this study please contact

André Bussi eres DC, FCCS (C), MSc

Questionnaire Index – Lumbar Spine X-rays

Section 1	Construct	Theory	Scale
			Low-High (1-7) Disagree/Agree Unlikely/Likely Little/Great Unimportant/Important
1	Evidence of Past behavior (1/1)	OLT	1-10
2a	Perceived Behavioural Control - direct (1/3)	TPB	
2b	Action Planning (2/3)	Planning	
2c	Evidence of habit (1/2)	OLT	Reverse coding
3a-e	Normative beliefs (5/5)	TIB	
4a	Action Planning (1/3)	Action P	
4b	Anticipated Consequences (2/3)	OLT	Reverse coding
4c	Moral Norm (2/3)	Moral Norm	
5a	Evidence of habit (2/2)	OLT	Reverse coding
5b	Perceived Behavioural Control – direct (2/3)	TPB	
5c	Intention (2/3)	TPB	
6a	Subjective Norms - direct 1/3)	TPB	
6b	Anticipated Consequences (3/3)	OLT	Reverse coding
7a-d	Perceived Behavioural Control (Strength of Control Belief x 4)	TPB	
8	Self-Reported Habit Scale (srhs x12)	TIB	
9a	Self-identity (Beliefs regarding characteristic of x-ray users x 3/3)	TIB	
9b	Subjective Norms - direct (3/3)	TPB	

9c	Intention (3/3)	TPB	
10a	Moral Norm (1/3)	Moral Norm	
10b	Action Planning (3/3)	Planning	
10c	Role beliefs (3/3)	TIB	
11	Behavioural Intention Performance - direct (1)	TPB	
12	Attitudes (Direct x 6 items) (same as TIB Affect)	TPB	
13a,b,c,e	Attitude (Outcome expectancy x 5)	TPB	Reverse coding
13 d			
14	Facilitating conditions x 8 items	TIB	
15 a-d	Perceived Behavioural Control (Perceived Power x 4)	TPB	Reverse coding
15e	Role beliefs (2/3)	TIB	
16a	Intention (1/3)	TPB	
16b	Subjective Norms - direct (2/3)	TPB	
16c	Perceived Behavioural Control - direct (3/3)	TPB	
17a	Moral Norm (3/3)	Moral Norm	
17b	Self-identity (Importance of these characteristics for themselves (corresponding 2/3)	TIB	
17c	Personal Norms (3/3)	TIB	
17d	Self-identity (Importance of these characteristics for themselves (corresponding 3/3)	TIB	
18a-c	Subjective Norm - indirect (Normative beliefs x 3)	TPB	
19a	Professional Norms (2/3)	TIB	
19b	Coping Planning	Planning	
19c	Professional Norms (3/3)	TIB	
20 a-e	Attitude (Outcome evaluation x 5)	TPB	
21a	Role beliefs (1/3)	TIB	
21b	Anticipated Consequences (1/3)	OLT	

21c	Personal Norms (1/3)	TIB	Reverse coding
21d	Self-identity (Beliefs regarding characteristic of x-ray users (1/3)	TIB	
22a	Coping Planning	Planning	
22b	Self-identity (Beliefs regarding characteristic of x-ray users (2/3)	TIB	
22c	Professional Norms (1/3)	TIB	
23a	Personal Norms (2/3)	TIB	Reverse coding
23b	Coping Planning (corresponding 2/3)	Planning	
23c	Self-identity (Importance of these characteristics for themselves (corresponding 1/3)	TIB	
24a-c	Subjective Norm - indirect (Motivation to comply x 3)	TPB	
Section 2	Behavioural Simulation (Scenarios)	-	
25-29			Sum of 5 cases
Section 3	Demographic	-	
1-10			

APPENDIX 6 FOCUS GROUPS RECRUITMENT MATERIALS

Letter of invitation for focus group interviews: Diagnostic Imaging Implementation Study

Dear colleague,

Although evidence-based diagnostic imaging guidelines are available, chiropractors remain divided on whether current guidelines recommendations for spine imaging apply to them. We are seeking participants who are willing to share their views on how best to assess patients with neck and back pain and as to the reasons why evidence-based recommendations on spine radiography may or may not be adopted in practice.

If you are maintaining a full time chiropractic practice (≥ 3 days/wk) and you agree to participate in this research, you will be interviewed about your experiences in managing neck and back pain and possible barriers and enablers likely to influence the implementation of recommendations included in a Diagnostic Imaging Guideline for Adult Spine Disorders (DIGASD). The proposed recommendations were published in the JMPT in 2008 ¹ and are posted on the websites of the American Specialty Health Network (ASHN) ² and the National Guidelines Clearinghouse ³ in 2009.

The focus group interview will be conducted in English in a small group of 4-6 chiropractors and will take approximately 60 to 90 minutes. The interview will take place on Thursday February 25th, 2010 at the ASHN headquarters where the upcoming continuing education conference will be held. The session will be audio-taped to provide an accurate record of the focus group's comments and a second researcher will also be present to take notes. To compensate for your time, expertise, and parking costs, focus group participants, like yourself, will be allowed to attend the February 26-27th, 2010 twelve (12) hour CE conference at ASHN and have their conference fee waved and be granted CE credit hours sufficient to meet the annual CEU requirements for the state of California*. ASHN is covering the conference fees.

We would also like you to be aware of the following information should you choose to participate:

- Participation in the research is entirely voluntary and you are free to withdraw at any time without penalty.
- You may ask questions of the researcher at any time and you may refuse to answer any of the questions without any negative consequences.
- Your identity will remain confidential and no identifying information will be provided in any reports or publications.
- When reporting our findings, no personal identifiers will be included and any quotes used to report our findings will not be revelatory of the participant's identity.
- Data will be kept for 15 years after study completion at which point they will be destroyed by shredding.
- Participation, or lack thereof, in this research will not affect your status with the ASHN in any way nor will ASHN have access to any information from the focus groups. ASHN's role in this project is limited to volunteering time and data and the CE hours as additional compensation to focus group participants.

Any inquiries about the research study should be addressed to Dr. André Bussi eres. Our staff will soon call your office to see if you are willing to participate to this study and to determine if you qualify to participate based on your practice profile and availability.

Thank you for supporting chiropractic research.
The research team

Andr  Bussi eres D.C., F.C.C.S. (C), M.SC., Ph.D. (candidate)
Principal investigator.

Research collaborator

*** FYI: This is the CEU program we are offering to you free of charge:**

Dates: February 26, 2010 (Friday) and February 27, 2010 (Saturday)

Program: 12 hours CEU total (Approved to meet the 12 hour requirements in CA)
Where: ASH

Speaker:

Subject: Physical/Differential Diagnosis

Date/Hours: Friday (2/26/10) 10 a.m.-2:30 p.m. (4 hours)

Lunch provided 12 noon-12:30 p.m.

Speaker: André Bussières, DC, FCCS (C), MSc, PhD (Candidate)

Subject: X-Ray/Radiography/Diagnostic Imaging

Date/Hours: Saturday (2/27/10) 6 a.m.-9.30 am. (4 hours)

Breakfast provided 5:30 a.m.-6 a.m.

Lunch provided 11 a.m.-11:30 a.m.

Speaker:

Subject: Adjustive Technique

Date/Hours: Saturday (2/27/10) 10:30 a.m.-2:30 p.m. (4 hours)

Open access for the DIGASD available at:

1. Diagnostic Imaging Practice Guidelines for Musculoskeletal Complaints in Adults--An Evidence-based Approach:

Part 3: Spinal Disorders. JMPT 2008; 31(1):33-88.

[http://www.journals.elsevierhealth.com/periodicals/ymmt/issues/contents?issue_key=S0161-4754\(08\)X0082-X](http://www.journals.elsevierhealth.com/periodicals/ymmt/issues/contents?issue_key=S0161-4754(08)X0082-X)

2. American Specialty Health Network: <http://www.ashcompanies.com/Resources/PDF/XRayGuidelines.pdf>

3. US National Guidelines Clearinghouse:

http://www.guideline.gov/summary/summary.aspx?doc_id=13009&nbr=006703&string=spine+AND+imaging



Information Sheet and Consent Form for Focus group interviews

Identifying factors likely to influence the use of diagnostic imaging guidelines for adult spine disorders among chiropractors' enlisted in a health maintenance organization

Principal Investigator: André Bussièrès DC, MSc, PhD (C)

Co-investigator: Jeremy Grimshaw MBChB PhD

PURPOSE: The objectives of this study are to investigate the experience of chiropractors in assessing patients with complaints of neck and back pain, and to identify factors likely to influence the use of x-rays during their first visit. We are conducting small group interviews to gather this information. Overall, four focus group interviews having 4-6 chiropractors will be conducted within different geographical locations in the US.

PROCEDURES: You are being asked to participate in a small group meeting to discuss your views on how best to assess patients with neck and back pain, and the reasons why evidence-based recommendations for spine radiography may or may not be adopted in your practice. The focus group is scheduled to take 1-1.5 hours and will be recorded in order to provide accurate record of what is said. The information will be transcribed from the tape. A note taker will be present to capture the suggestions and comments of participants.

RISKS: There are no known risks to participants.

BENEFITS: To compensate for your time, expertise, and parking cost, you will be allowed to attend, at no charge, a twelve (12) hour CE conference meeting the annual California CE requirements held in the International Conference room at ASHN headquarters downtown San Diego (February 26-27th, 2010). You will be granted 12 CE credit hours through sponsorship by Southern California University of Health Sciences (SCUHS). Other foreseen benefits include optimizing your practice, and meeting some quality improvement objectives of ASHN. Your participation in this research may allow the researchers to gain in depth understanding of how best to transfer new knowledge to chiropractors. This in turn may be of benefit to future patients.

RIGHTS OF PARTICIPANTS: You are under no obligation to participate in the study and have the right to withdraw at any time without any effect. You will not have any penalty or loss of benefits to which you are otherwise entitled to. You have the right not to answer any question(s) you choose.

Identifying factors likely to influence the use of diagnostic imaging guidelines for adult spine disorders among chiropractors' enlisted in a health maintenance organization

CONFIDENTIALITY: Organizations that may audit the study records include the Ottawa Hospital Research Ethic Board, and the Ottawa Hospital Research Institute.

The link between your name and the independent study number will only be accessible by Drs. A. Bussièrès and J. Grimshaw and their staff. The audiotape is erased once the transcript has been verified. All potentially identifying information about you will be deleted from the transcript. The information collected during the study will be kept confidential. You will not be identified in any subsequent publication/reports or presentations. All paper records will be stored in a locked office. All electronic records will be stored at the Ottawa Hospital Research Institute and protected by a user password, again only accessible by Drs. Bussièrès and Grimshaw and their staff. The study data will be kept for 15 years after termination of the study.

QUESTIONS ABOUT THE STUDY

If you have any questions about this study, please contact Dr. André Bussièrès, DC, FCCS(C), MSc, PhD (Candidate).

The Ottawa Hospital Research Ethics Board (OHREB) has reviewed this protocol. The OHREB considers the ethical aspects of all research studies involving human subjects at The Ottawa Hospital. If you have any questions about your rights as a research subject, you may contact the Chairperson of the Ottawa Hospital Research Ethics Board,

VOLUNTARY PARTICIPATION

Your participation in this study is voluntary. If you choose not to participate, your decision will not affect the care you receive at this Institution at this time, or in the future. You will not have any penalty or loss of benefits to which you are otherwise entitled to.

**CONSENT FORM*****Identifying factors likely to influence the use of diagnostic imaging guidelines for adult spine disorders among chiropractors' enlisted in a health maintenance organization*****Consent to Participate in Research**

I understand that I am being asked to participate in a research study about my professional experience in evaluating neck and back pain patients and perceived barriers to implementing a diagnostic imaging guidelines. This study has been explained to me by Dr André Bussi eres, DC, MSc, PhD (candidate).

I have read this 3 pages Patient Information Sheet and Consent Form (or have had this document read to me). All my questions have been answered to my satisfaction. If I decide at a later stage in the study that I would like to withdraw my consent, I may do so at any time.

I voluntarily agree to participate in this study.

A copy of the signed Information Sheet and/or Consent Form will be provided to me.

Please check the appropriate boxes:

If clarification is required following the focus group, may we contact you? **yes** **No**

Signatures

Participant's Name (Please Print)

Participant's Signature

Date

Investigator Statement (or Person Explaining the Consent)

I have carefully explained to the research participant the nature of the above research study. To the best of my knowledge, the research participant signing this consent form understands the nature, demands, risks and benefits involved in participating in this study. I acknowledge my responsibility for the care and well being of the above research participant, to respect the rights and wishes of the research participant, and to conduct the study according to applicable Good Clinical Practice guidelines and regulations.

Name of Investigator/Delegate (Please Print)

Signature of Investigator/Delegate

Script for the Introduction of the Focus group Interviews***Introduction by interviewer***

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'My name is André Bussi eres, and this is _____. I would first like to thank you for accepting taking part to this group interview. The general aim of the interview is to enable us to understand how you manage patients presenting with neck and back pain and what are the perceived barriers and facilitators for implementing some recommendations from a Diagnostic Imaging Guidelines for Adults Spine Disorders in you own clinic. This interview is based on multiple related theories to help us understand care provider's practice, so some question may sound similar.

I would like to invite everyone to briefly introduce him/herself and tell us in what setting you practice, for example in a large or small city or in a rural area.

"I'm just going to read you a brief description of what we are doing today, which we are reading to everyone we interview."

"Our goal today is to talk about how you manage new patients presenting with neck or back pain. Also, we are interested in knowing what problems if any, you may see in implementing the imaging guidelines in your daily practice. We are here to listen to your experiences to help us to understand these two issues better".

"You should have received an e-mail containing the invitation letter with links to websites for you to review key recommendations in the Diagnostic Imaging Guidelines for Adults Spine Disorders as well as the full guidelines. We are interested in knowing your thoughts on this. If you didn't have a chance to review it, please take a few minutes to do so now."

There are a few things I'd like to touch on before we get started:

1. Any discussion that occurs in this room stays in this room. All of the information that is shared with us is confidential. You can feel free to say what you like related to the topic at hand.
2. Your participation in this interview is voluntary. You can choose not to answer any of the questions if you don't want to, and you are free to leave at any time with no consequences, including without loss of incentive.
3. There are no right or wrong answers. We are interested in understand perspectives about managing spine disorders and using x-rays, so please answer frankly.
4. You shouldn't feel that you have to agree with everyone else in this room if that's not how you really feel. There are _____ people here, so we expect that people will have different views. And it's important that we learn from all of the views that are represented here.
5. We want you to feel comfortable saying good things as well as critical things. We're not here to promote a particular ways of thinking about how to manage patients or about using x-ray guidelines. We just want to understand how clinicians such as your selves make sense of it.

6. We ask that you talk one a time so that we can be sure to hear everyone's views and get them on tape.
7. I would like to remind you that this interview will be taped to preserve the maximum information you will share with us. As mentioned in the informed consent, once the transcription will be completed your name will no longer appear on the documents.
8. (Identify notetaker) Though we have someone taking notes of what is said in the interview, we also plan to record our discussion because it is important that we keep track of everything that is said during the interview. This will help us get the most accurate account of what is said and this will also help the notetaker in case the conversation speeds up and they are not able to write everything down. Is it okay with you that we record the session?
9. When you first say something, please say your name so that the person transcribing the tape will know who is talking.
10. If you have a cell phone or pager, I would ask that you please make sure this is turned off before we start.
11. And lastly, the session will take between 60 to 90 minutes. Please let me know if you need to take a break at anytime.

Are you ready to start?

APPENDIX 7 SURVEY QUESTIONNAIRE RECRUITMENT MATERIALS

INVITATION POSTCARD FOR CHIROPRACTORS' RECRUITMENT

AN INVITATION

Dear Colleague :

You are being asked to participate in a study of chiropractor' views on ***routine x-ray ordering for uncomplicated low back pain patients***. The aim of our research is to find out if psychological concepts of behaviour can help us understand chiropractor behaviours such as ordering spine x-rays. The final results will be used to design improved strategies and methods for bringing new research findings into practice. In approximately one week, we will mail you the questionnaire. Should you complete the questionnaire your name will be entered in a draw for one of twenty \$250 gift cards from Amazon, as a token of our appreciation as well as to compensate you for your time.

We would very much appreciate your input to our work. If you have any questions or concerns, please do not hesitate to contact me via email.

Sincerely,

Dr André Bussi eres, DC, MSc, FCCS
This work is being done in partial fulfillment of a PhD

Dr.Jeremy Grimshaw, MBChB, PhD, FRCGP
Senior Scientist

Ottawa Hospital Research Institute

**COVER LETTER FOR CHIROPRACTORS' RECRUITMENT****Identifying factors predictive of guidelines uptake for spine x-rays**

Dear colleague,

Although evidence-based diagnostic imaging guidelines are available, chiropractors remain divided on whether current guidelines recommendations for spine imaging apply to them. The overall goal of this research is to improve knowledge transfer and uptake of recommendations included in a diagnostic imaging guideline for spine disorders⁴ among chiropractors in the province of Ontario.

Results from a previous study have provided us with a better understanding of the reasons why chiropractors may or may not implement recommendations for spinal imaging studies. We now seek participants who are willing to complete the attached questionnaire. The objective of this study is to identify factors that may predict taking spine radiography.

You will find along with this invitation, a questionnaire pertaining to your management strategies of patients with uncomplicated back pain, as well as simple questions assessing general intentions to manage back pain without x-rays. For example: *I intend to take radiographs of most patients as part of their management; I intend to only take radiographs of patients presenting with red flag(s)...* This package also includes a reply envelope.

We anticipate only about 35 minutes are needed to answer the survey. Upon receipt of the duly completed postal or online survey questionnaire, your name will be entered for a draw to win one of twenty \$250 gift cards from Amazon to thank you for taking the time to participate.

We would also like you to be aware of the following information should you choose to participate:

- Participation in the research is entirely voluntary and you are free to withdraw at any time without penalty.
- Your identity will remain confidential and no identifying information will ever be reported.
- When reporting our findings no personal identifiers will be included.
- All data will be destroyed 15 years after study completion.

Any inquiries about the research study should be addressed to Dr. André Bussi eres.

Thank you in advance for participating in this study.

Dr Andr e Bussi eres, DC, MSc, FCCS

This work is being done in partial fulfillment of a PhD

Dr.Jeremy Grimshaw, MBChB, PhD, FRCGP

Senior Scientist

INFORMATION SHEET AND CONSENT FORM

Individual factors influencing use of spine x-rays

Principal Investigator: Jeremy Grimshaw MBChB PhD

Co-investigator: André Bussières DC, MSc, FCCS

Sponsor: Funded by the Canadian Institutes of Health Research

Introduction

You are being asked to participate in this research project because, as a licensed chiropractor, you regularly manage patients with back pain and have the privilege to take or order spine x-rays.

Please read this 'Information Sheet and Consent Form' carefully and ask as many questions as you like before deciding whether to participate in this research study. You can discuss this decision with your colleagues.

Background, Purpose and Design of the Study: One of the most consistent findings in health services research is that the transfer of research findings into practice is unpredictable and can be a slow and haphazard process. The objectives of this study are to assess the relevance of barriers and facilitators to professional behavioral change we have previously identified in a related study, and to try to predict characteristics of chiropractors' that may be influenced in order to improve adherence to evidence-based recommendations for the radiological evaluation of uncomplicated back pain. The study design is a survey questionnaire.

Study Procedures: You are being asked to complete a survey questionnaire that seeks to identify potential predictors of the ordering of lumbar spine x-rays to improve compliance with imaging guidelines recommendations for patients with back complaints. The invitation pack you received should include the

following: a letter of invitation, a questionnaire consisting of demographic, outcome and predictive measures, a pre-posted reply envelope, and consent form to participate. We anticipate only about 35 minutes are needed to answer the survey questionnaire.

Possible Side Effects and/or Risks: There are no known risks to participants.

Benefits of the Study: None.

Your participation in this research may allow the researchers to gain in depth understanding of how best to transfer new knowledge to chiropractors. This in turn may be of benefit to future patients.

Confidentiality: Organizations that may audit the study records include the Ottawa Hospital Research Ethic Board (OHREB) and the Ottawa Hospital Research Institute (OHRI). No identifying information will be reported in any publications, reports or presentations. Confidentiality of the data will be protected by assigning each participant such as yourself a unique identification number replacing the name and the registration number of care providers and using that number on all data about participation. All paper records will be stored in a locked office. All electronic records will be stored at the administrative Services Building, OHRI and protected by a user password. The study data will be kept for 15 years after termination of the study and then destroyed. You will not be identified in any subsequent publication/reports or presentations.

Cost: Once we receive your completed questionnaires, your name will be entered for a draw to win one of twenty \$250 gift cards from Amazon.

Voluntary Participation: You are under no obligation to participate in the study and have the right to withdraw at any time without any effect. You will not have any penalty or loss of benefits to which you are otherwise entitled to. You have the right not to answer any question(s) you choose.

New Information about the Study: You will be told of any new findings during the study that may affect your willingness to continue to participate in this study. You may be asked to sign a new consent form.

Questions about the Study: If you have any questions about this study, please contact Dr. André Bussi eres, DC, MSc, FCCS

The Ottawa Hospital Research Ethics Board (OHREB) has reviewed this protocol. The OHREB considers the ethical aspects of all research studies involving human subjects at The Ottawa Hospital. If you have any questions about your rights as a research subject, you may contact the Chairperson of the Ottawa Hospital Research Ethics Board.

REMINDER POSTCARD FOR CHIROPRACTORS' RECRUITMENT

A Reminder

Dear Colleague:

You have been asked to participate in a study of chiropractor' views on routine x-ray ordering for uncomplicated low back pain patients. The aim of our research is to find out if psychological concepts of behaviour can help us understand chiropractor behaviours such as ordering spine x-rays. The final results will be used to design improved strategies and methods for bringing new research findings into practice. In approximately one week, we will mail you the questionnaire. Should you complete the questionnaire your name will be entered in a draw for one of twenty \$250 gift cards from Amazon, as a token of our appreciation as well as to compensate you for your time.

We would very much appreciate your input to our work. If you have any questions or concerns, please do not hesitate to contact me by e-mail.

Sincerely,

Dr André Bussi eres, DC, MSc, FCCS
This work is being done in partial fulfillment of a PhD

Dr.Jeremy Grimshaw, MBChB, PhD, FRCGP
Senior Scientist

Ottawa Hospital Research Institute

Ottawa Hospital Research Institute



Re: PRIme Plus Questionnaire for chiropractors X-ray Ordering Practices

Dear Dr.

This letter is a follow-up to a reminder you recently received requesting your participation in a research project. The project is studying whether chiropractors' views about routine spine x-rays influences their test ordering practices. The ultimate goal of our project is to design improved strategies and methods for bringing new research findings into practice. **The purpose of this questionnaire is to better understand chiropractor' views on the use of x-rays in otherwise healthy patients. We are particularly interested in the role of lumbar spine x-rays for uncomplicated low back pain patients.** This questionnaire should take no more than 35 minutes to complete.

You are under no obligation to participate in the study and you may withdraw at any time without any repercussions. Research staff will respect your wish to stop postal reminders. You have the right not to answer any question(s) you so choose.

Once we receive your completed questionnaire, your name will be entered for a draw to win one of twenty \$250 gift cards from Amazon.

The information collected during the study will be kept confidential. Your responses are confidential, but we have written an identifying number on your questionnaire for our record keeping - this will allow us to identify your returned questionnaire so no follow up reminders will be sent to you. **You may return your survey in the pre-addressed envelope provided.** The Study data will be kept for 15 years after termination of the study and then destroyed. The Ottawa Hospital Research Ethics Board and the Ottawa Hospital Research Institute may audit your relevant study records for auditing purposes. Should you decide not to complete the questionnaire, please return it to us so that we may remove your name from our list and no further correspondence will be sent.

Should you have any questions regarding this study, you may contact me, Dr. André Bussièrès me or Andrea Patey. If you have any questions about your rights as a research participant please contact the Chairman of the Ottawa Hospital Research Ethics Board.

Thank you in advance for participating in this study.

Dr André Bussièrès, DC, MSc, FCCS
This work is being done in partial fulfillment of a PhD

Dr. Jeremy Grimshaw, MBChB, PhD, FRCGP
Senior Scientist

APPENDIX 8 RESEARCH ETHICS BOARD CERTIFICATES



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Ottawa Hospital Research Ethics Boards
Conseils d'éthique en recherches

725 Parkdale Avenue, Box 411, Ottawa, Ontario K1W 4E9 613-796-5555 ext. 14902 Fax: 613-761-4311
<http://www.ohrt.ottahosp>

December 24, 2010

Dr. Jeremy Grimshaw

Dear Dr. Grimshaw:

Re: Protocol # Identifying Factors Likely to Influence the Use of Diagnostic Imaging Guidelines for Adult Spine Disorders Among Chiropractors' Enlisted in a Health Maintenance Organization in the United States

Thank you for the letter of December 13, 2010 from Andrea Paley in response to our email correspondence of the same day. I am pleased to inform you that the following documentation is approved:

- Protocol Amendment Report, dated September 21, 2010
- New English Information Sheet and Consent Form for Focus Group Interviews, version 1, December 13, 2010 (USA)
- New English Information Sheet and Consent Form for Focus Group Interviews, version 1, December 13, 2010 (Canada)

We acknowledge that Dr. Grimshaw has taken over as Principal Investigator and Dr. Bussières has taken over as Co-Investigator. The file has been updated accordingly.

Ethical approval remains in effect until February 24, 2011.

Chairman
Ottawa Hospital Research Ethics Board



uOttawa

**Ottawa Hospital Research Ethics Boards
Conseils d'éthique en recherches**

725 Parklawn Avenue, Ottawa, Ontario K1W 4E9 613-796-5555 ext. 14502 Fax: 613-761-4311
http://www.ohrebo.org

August 8, 2011

Dr. Jeremy Grimshaw

Dear Dr. Grimshaw:

RE: Protocol#- Identifying Factors Likely to Influence the Use of Diagnostic Imaging Guidelines for Adult Spine Disorders Among Chiropractors' Enlisted in a Health Maintenance Organization in the United States. Part 1. Describing Current Practice Patterns and the Impact of Initial Guidelines Dissemination

Renewal Expiry Date- August 7, 2012

Thank you for the letter of August 4, 2011 from Andrea Paley. I am pleased to inform you that your Annual Renewal Request (listed above) was reviewed by the Ottawa Hospital Research Ethics Board (OHREB) and is approved. No changes, amendments or addenda may be made in the protocol without the OHREB's review and approval.

Renewal is valid for a period of one year. Approximately one month prior to that time, a single renewal form should be sent to the OHREB office.

The Tri-Council Policy Statement requires a greater involvement of the OHREB in studies over the course of their execution. As well, you must inform the Board of adverse events encountered during the study, here or elsewhere, or of significant new information which becomes available after the Board review, either of which may impinge on the ethics of continuing the study. The OHREB will review the new information to determine if the protocol should be modified, discontinued, or should continue as originally approved.

Chairman
Ottawa Hospital Research Ethics Board



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**Ottawa Hospital Research Ethics Boards
Conseils d'éthique en Recherche**

725 Parklala Avenue, Suite 411, Ottawa, Ontario K1W 4E9 613-796-5555 Fax: 613-761-4311

September 16, 2011

Dr. Jeremy Grimshaw

Dear Dr. Grimshaw:

Re: Protocol # **Identifying Factors Likely to Influence the Use of Diagnostic Imaging Guidelines for Adult Spine Disorders Among Chiropractors' Enlisted in a Health Maintenance Organization in North America. Part 3. Individual and Collective Factors Predictive of Imaging Guidelines Update. A Predictive Study (Protocol)**

Protocol approval valid until- September 15, 2012

Thank you for your letter dated September 7, 2011. I am pleased to inform you that this protocol underwent expedited review by the Ottawa Hospital Research Ethics Board (OHREB) and is approved. No changes, amendments or addenda may be made to the protocol or the consent form without the OHREB's review and approval.

Approval is for the following documentation: Protocol received June 17, 2011

English Postal Reminder Cards for ASHN Chiropractors received July 19, 2011

English Postal Reminder Cards for Canadian Chiropractors received July 19, 2011

English Information and Consent Form for ASHN Chiropractors dated July 2011

English Information and Consent Form for Canadian Chiropractors dated July 2011

English Dear Colleague letter (follow-up to invitation) for ASHN Chiropractors received September 7, 2011

English Dear Colleague letter (follow-up to invitation) for Canadian Chiropractors received September 7, 2011

English Dear Colleague letter (follow-up to reminder) for ASHN Chiropractors received July 19, 2011

English Dear Colleague letter (follow-up to reminder) for Canadian Chiropractors received July 19, 2011

English Questionnaire for ASHN Chiropractors received September 7, 2011

English Questionnaire Canadian Chiropractors received September 7, 2011

The validation date should be indicated on the bottom of all consent forms and information sheets (see copy attached). If the study is to continue beyond the expiry date noted above, a Renewal Form should be submitted to the OHREB approximately six weeks prior to the current

expiry date. If the study has been completed by this date, a Termination Report should be submitted.

The Ottawa Hospital Research Ethics Board is constituted in accordance with, and operates in compliance with the requirements of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans; Health Canada Good Clinical Practice: Consolidated Guideline; Part C Division 5 of the Food and Drug Regulations of Health Canada; and the provisions of the Ontario Health Information Protection Act 2004 and its applicable Regulations.

Yours sincerely,

Chairman
Ottawa Hospital Research Ethics Board

Encl.