INTERVENTION FIDELITY WITHIN INTERVENTIONS AIMED AT REDUCING NON-INDICATED IMAGING FOR LOW BACK PAIN

by © Daphne K To

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Abstract

Non-indicated imaging for low back pain (LBP) is unnecessary but remains common. Interventions to reduce this behaviour must consider the impact of fidelity (i.e., degree to which the intervention was delivered as intended) on trial results. The thesis examines strategies used to enhance and assess intervention fidelity for interventions targeting non-indicated imaging for LBP and explores perceived barriers and enablers to enhancing fidelity of training and delivery to a proposed intervention for reducing non-indicated imaging for LBP. Two studies, a systematic review and a qualitative interview study, address these objectives. The systematic review, conducted using the PRISMA statement, found few studies reported strategies to enhance/assess fidelity. When reported, mainly enhancement strategies for fidelity to study design and intervention delivery were identified. The interview study, analysed with the Theoretical Domains Framework, found that logistical issues were a perceived barrier to attending training, while enablers were incentives and flexibility in training. Time, patient pressures, and habit were perceived barriers to intervention delivery, while enablers included enhancement strategies related to reminders and support. Findings from this thesis contribute to the development of an intervention fidelity protocol when designing an intervention to reduce non-indicated imaging for LBP in Newfoundland and Labrador, Canada.

Keywords: intervention fidelity; low back pain; imaging

General Summary

Most patients with low back pain (LBP) do not need medical imaging. Interventions to reduce imaging have been developed, but with variable effectiveness. Intervention fidelity, delivering the intervention as intended, may be a reason why. This thesis reviewed existing literature on intervention fidelity for interventions to reduce LBP imaging and included an interview study exploring perceived barriers and enablers to enhancing fidelity to provider training (i.e., attending training) and intervention delivery for a proposed intervention to reduce LBP imaging in Newfoundland and Labrador, Canada. We found few studies reported on fidelity; those that did mostly reported enhancement strategies. Barriers to attending training include logistical issues; enablers include incentives and training flexibility. Barriers to intervention delivery include time, patient pressure, and habits; enablers include enhancement strategies related to reminders and support. Findings from this thesis contribute to the intervention literature generally and will inform a planned study to reduce LBP imaging.

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List of Abbreviations

BCT: behaviour change technique

CBA: controlled before-after

CDS: clinical decision support

CT: computed tomography

DC: doctor of chiropractic

GP: general medical practitioner

ITS: interrupted time series

LBP: low back pain

MRI: magnetic resonance imaging

N/A: Not applicable

NIHBCC: National Institutes of Health Behavior Change Consortium

NL: Newfoundland and Labrador

RCT: randomised controlled trial

TDF: Theoretical Domains Framework

UBA: Uncontrolled before-after

UK: United Kingdom

US: United States

YLDs: years lived with disability

List of Appendices

Declaration of Publication Intent

These chapters have not been published in a peer-reviewed journal; therefore, no figures or tables are copyrighted. However, two main chapters (Chapters 3 and 4) will be submitted to open access, peer-reviewed journals for publication.

Chapter 1: Introduction

Non-specific low back pain is a common condition that is experienced by many people over their lifetime. Many factors, such as biophysical, psychological, and social factors, contribute to a patient's experience of non-specific low back pain, but often, the pathoanatomical cause of pain is undetermined. Therefore, diagnostic imaging is usually not appropriate for the management of patients with non-specific low back pain. Despite various clinical practice guidelines recommending against the use of diagnostic imaging for the management of non-specific low back pain, it continues to be commonly used in primary care practices, and various interventions have been designed and used to reduce the use of non-indicated imaging. Many of these interventions have shown varying levels of effectiveness and one factor influencing the level of effectiveness is the lack of intervention fidelity.

Intervention fidelity refers to the degree to which an intervention is implemented as intended by the intervention developers. The reporting of strategies to enhance and assess intervention fidelity has not been evaluated within the literature on interventions designed to change physician behaviour to reduce non-indicated imaging for low back pain. Therefore, the overall objective for this thesis was to examine strategies that have been used to enhance and assess intervention fidelity for interventions targeting physician behaviour to reduce non-indicated imaging for low back pain, as well as to explore perceived barriers and enablers to enhancing fidelity of training and fidelity of delivery to

a proposed intervention for reducing non-indicated imaging for low back pain. To achieve these objectives, this thesis will be comprised of two studies: the first study will be the first systematic review to comprehensively examine the strategies which have been used to enhance and assess intervention fidelity for interventions targeting physician behaviours (Chapter 3), while the second will be a qualitative interview study on general practitioners' and chiropractors' perceived barriers and enablers for enhancing fidelity of training and fidelity of delivery (Chapter 4). This thesis contributes to the literature on intervention fidelity for interventions aimed at reducing non-indicated imaging for low back pain, an area of implementation research which has previously mostly been unaddressed.

Chapter 2: Background Literature Review

The purpose of this chapter is to provide an overview of the available literature related to the main concepts in this thesis. This chapter will also highlight gaps in the literature, which form the rationale for conducting the studies in this thesis.

2.1 Non-specific low back pain

2.1.1 Etiology

Low back pain (LBP) is a common symptom that is defined by a location typically between the lower rib margins and the gluteal folds (1) and may be accompanied by pain in the lower extremities (2). Low back pain can be classified as specific or non-specific. Specific LBP can arise from specific disorders of the lumbar spine (e.g., vertebral fracture, malignancy, axial spondyloarthropathy) or from conditions beyond the lumbar spine (e.g., abdominal aortic aneurysm) (2-4). Non-specific LBP is the most common form of LBP and is defined as LBP where the pathoanatomical cause of pain cannot be determined (3), but instead likely develops due to an interaction of biophysical (e.g., prolonged postures, heavy lifting, smoking, obesity), psychological (e.g., psychological distress, depression), and social (e.g., socioeconomic status, health literacy) factors, as well as the presence of other comorbid conditions (2, 4).

2.1.2 Epidemiology

Current literature suggests that approximately 90% of LBP is non-specific (5). Specific diagnoses of LBP (as defined previously in section 2.1.1 Etiology) account for less than 5 to 10% of LBP presentations in primary care (6). In an Australian study of 1172 patients receiving primary care for acute (< 6 weeks) LBP, less than 1% of the cases (11 cases) had serious pathology, of which fracture was the most common (8/11 cases), followed by inflammatory disorder (2/11 cases) (7). In a Dutch study of 669 older adults (> 55 years of age) presenting to primary care with back pain, approximately 6% were diagnosed with a serious pathology, of which fracture was the most common (5%), followed by spinal malignancy (1%) (8).

According to data extracted from the Global Burden of Disease, Injuries, and Risk Factors 2017 study (9), the age-standardised point prevalence of LBP decreased from 8.20% in 1990 to 7.50% in 2017; however, the estimated prevalent numbers of people with LBP increased from 377.5 million in 1990 to 577.0 million in 2017, due to the increase in global population (10). The prevalence of LBP increases with age, peaking at around 80-89 years of age, and is more common in females than males (10). Low back pain is the leading cause of years lived with disability (YLDs) globally; LBP was responsible for approximately 64.9 million YLDs in 2017, representing an increase of 53% since 1990 (10). Disability from LBP increases with age, peaking at 45-49 years of age, before decreasing (10). This peak age group corresponds to working age groups

worldwide, which is thought to be concerning particularly in low- to middle-income countries where possibilities for job modifications and occupational health and safety policies may be absent (2).

2.1.3 Clinical course and prognosis

The clinical course of LBP varies over an individual's life (2, 4). Data from a systematic review and meta-analysis on the clinical course of pain and disability in patients with LBP supports that while most patients have substantially improved pain and disability scores after six weeks, low to moderate levels of pain and disability were still reported after one year (11). Several recovery patterns have been identified from research on trajectories for LBP, which include pain improvement (e.g., rapid or gradual improvement), persistent pain (e.g., at mild, moderate, or severe pain intensities), and fluctuating pain (e.g., variations in mild, moderate, or severe pain intensities) (12). Research on risk factors for new episodes of LBP has also shown that previous episodes for LBP increases the risk of new episodes of LBP (13). Therefore, the current literature suggests LBP may be a longer-lasting condition with a variable course and related episodes, instead of the traditional classifications of LBP by duration (i.e., acute, subacute, chronic) or recovery (i.e., recovered, recovering, not recovered) and unrelated episodes (2, 4, 12).

Just as biophysical, psychological, and social factors may contribute to the development of LBP, these factors may also contribute to an individual's experience of LBP,

particularly related to a poor clinical outcome (e.g., persistent pain or disability) (2). Potential physical prognostic factors associated with a poor outcome include the presence of widespread pain, having poor physical functioning, high pain intensity, and longer pain durations (14). Potential psychological prognostic factors associated with a poor outcome include higher levels of depression and/or anxiety, poor coping strategies, somatisation, catastrophizing, and having fear avoidance beliefs (2, 14); however, these factors likely interact and the reasons why these factors relate to poorer outcomes of pain and/or disability are poorly understood (2). Potential social prognostic factors associated with a poor outcome include lower socioeconomic status, lower levels of education, and increased physical workloads (2, 14). Overall, many factors may interact to impact the variable clinical course of LBP.

2.2 Diagnostic imaging for non-specific low back pain

2.2.1 Evidence-based recommendations for imaging

Diagnostic imaging, including x-ray, computed tomography (CT), and magnetic resonance imaging (MRI), is a diagnostic tool that can be important for identifying specific pathology and is used in the management of a variety of clinical conditions. However, diagnostic imaging may have limited clinical utility, and thus is not always appropriate for the management of non-specific LBP, a clinical condition with a variety of contributing factors, without an identifiable cause (3, 4).

Current clinical practice guidelines for the management of patients with non-specific LBP recommend against the use of routine imaging (15, 16). A review that provides an overview of recommendations on the diagnosis and treatment of patients with non-specific LBP in primary care identified 15 clinical practice guidelines globally (15). While all guidelines recommended against the use of routine imaging, the recommendations for when imaging should be considered varied between the guidelines. Most (seven) guidelines recommended that imaging should only be considered in the presence of red flags. Five guidelines recommended imaging when the results were likely to change or direct treatment, and two guidelines recommended imaging if pain persisted beyond 4 to 6 weeks (15). Accordingly, the College of Family Physicians of Canada, as part of their Choosing Wisely Canada recommendations, recommends not imaging for LBP unless red flags are present, since lumbar spine imaging before six weeks does not improve outcomes (17). These red flags include severe or progressive neurological deficits or when serious underlying conditions are suspected (17).

Although most guidelines include a recommendation for not imaging unless red flags were present, the guidelines lack consistency on which red flags should be considered when trying to identify patients who are at risk for a serious underlying spinal pathology (18). Systematic reviews on the diagnostic accuracy of red flags for malignancy demonstrated that few studies have reported data on diagnostic accuracy (19, 20). Only the red flag of "history of cancer" suggested a post-test probability of 7% in primary care (i.e., the probability of malignancy if the patient had a history of cancer is 7%) (20). However, other commonly cited red flags for malignancy such as older age, unexplained

weight loss, and failure to improve after one month only had a post-test probability of below 3% (20), suggesting that these red flags, particularly when used in isolation, may not be helpful in identifying patients at risk for malignancy. Of the red flags for a spinal fracture, a combination of red flags including three of female, age over 70 years, severe trauma, and prolonged corticosteroid use increased the probability of having a spinal fracture to 90% (20). Diagnostic accuracy data is sparse for red flags for other spinal pathologies such as cauda equina syndrome, spinal infection, or axial inflammatory disorders. Thus, clinical decision making is still required to interpret identified red flags within the context of the patient's clinical presentation (18).

2.2.2 Use of imaging in primary care

Despite current guideline recommendations, non-indicated imaging remains common globally (16). A recent systematic review describing usual care provided by primary care physicians to patients with LBP suggests that approximately 25% of patients with LBP receive referrals for imaging (21). Another systematic review and meta-analysis examining the prevalence of overuse and/or underuse of imaging in primary care found that in patients referred for imaging, about one third had imaging that was inconsistent with guideline recommendations (22).

Many barriers to following evidence-based recommendations for imaging have been reported in the literature. Among physicians, imaging behaviour appears to be influenced by patients requesting imaging (i.e., patient expectations), physicians believing that

providing a scan will reassure patients, time constraints, diagnostic uncertainty, lack of guideline awareness, perceiving that imaging is important to locate the source of pain, and a fear of missing a diagnosis (23-25). Similarly, among chiropractors, imaging behaviour may be influenced by their colleagues and patients, a fear of potential negative consequences of not ordering imaging (e.g., missing a diagnosis), a lack of confidence and comfort in managing patients without imaging, and a lack of guideline awareness and agreement (26, 27). Patient beliefs about diagnostic imaging may also be a barrier to following evidence-based recommendations for imaging, as it has been reported that patients often believe diagnostic imaging is important for locating the source of pain, as well as for validating their pain experience (25).

2.3 Interventions aimed at reducing non-indicated imaging for low back pain

Many interventions have been used to improve the appropriate use of imaging for musculoskeletal conditions, including LBP. Examples of these interventions include guideline dissemination, various forms of clinician education, audit and feedback, and clinical decision support tools (28-30). However, the effectiveness of those interventions has been variable. A 2010 Cochrane review by French and colleagues (28) included six studies on interventions targeting imaging for patients with LBP only. While the majority of the studies used the distribution of educational materials (e.g., guidelines) as the intervention, there were varying effects when compared to no-intervention controls (28); therefore, it was unclear whether the distribution of educational materials was an effective

intervention or not. A 2015 systematic review investigating the effectiveness of interventions aimed at reducing the use of imaging for LBP included seven studies and divided the interventions into four categories: clinical decision support and targeted reminders, audit and feedback, practitioner education, and postal guideline dissemination (29). Clinical decision support tools, including modified referral forms, and targeted reminders to physicians were the most effective interventions in reducing the use of imaging for LBP (29). Modified referral forms used in a hospital setting reduced imaging by 36.8% (95% confidence interval 33.2% - 40.5%), while targeted reminders to primary care physicians reduced referrals for imaging by 22.5% (95% confidence interval 8.4% - 36.8%) (29). Other interventions did not significantly reduce imaging rates or had variable results; however, the small number of studies and lack of sufficient power within the studies may limit the interpretation of the results (29). Similarly, a recent review which included mostly interventions using clinician education to improve guideline-recommended imaging referrals for LBP found that these interventions had no effect (30).

2.3.1 Understanding variation in effectiveness of interventions

There are different reasons why effectiveness of the same (or similar) intervention(s) may vary from one study to another, such as differences in populations, clinical settings, local context, and implementation processes. Within interventions targeting primary care practitioners to improve the appropriate use of imaging for LBP, two potential reasons for this variation in effectiveness suggested in the literature are a lack of intervention rationale/theoretical underpinning and poor intervention fidelity (28, 31).

Through using a theoretical framework, a better understanding of the factors influencing a particular behaviour can be developed, which then allows for the selection of behaviour change techniques (BCTs) that are most suitable for the target behaviour (32). A theoretical framework which has been used in the development and examination of the implementation of health behaviour change interventions is described in greater detail in section 2.4 Investigating Behavioural Change: The Theoretical Domains Framework. Interventions designed without using a theoretical framework may result in the intervention not targeting the actual barriers to performing the target behaviour. Therefore, Hall and colleagues conducted a systematic review to analyse the BCTs that have been used within interventions aimed at improving adherence to evidence-based LBP imaging (31) to determine whether interventions targeted the known barriers identified in the literature described previously (in section 2.2.2 Use of imaging in primary care). The most frequently used BCTs were based on education of physicians (e.g., through guideline dissemination or educational seminars/workshops) to target their knowledge and skills (31). Feedback on their behaviour (e.g., through electronic feedback reports) was also commonly used (31). These commonly used BCTs primarily target knowledge and skills; however, the barriers identified in the literature (described in section 2.2.2 Use of imaging in primary care) are beyond just lack of knowledge and skills. For example, patient requests for imaging may be a social influence acting as a barrier to the appropriate use of imaging for LBP, while time constraints during a clinical encounter may be an environmental barrier which needs to be targeted by an intervention aiming to improve the appropriate use of imaging for LBP. Therefore, the effectiveness of

such interventions may be influenced by more than simply identifying barriers for the target behaviour.

The effectiveness of interventions may also vary across studies due to poor intervention fidelity; that is, the interventions may not have been delivered or implemented as intended (33, 34). In this situation, study results may show that an intervention has a non-significant effect, but essential components may have been omitted from the intervention (35), resulting in poor intervention fidelity. If there was poor intervention fidelity during the implementation of the intervention, the interpretation of study results will become challenging. The concept of intervention fidelity in the context of health behaviour change research and how it impacts the interpretation of study results is described in greater detail in section 2.5 Intervention fidelity.

2.4 Investigating Behavioural Change: The Theoretical Domains Framework

2.4.1 Development

Behaviour change interventions informed by theory may be more effective than those that are not; however, many behaviour change theories with overlapping constructs have been used within health behaviour change literature (36). An issue with having so many theories and theoretical constructs is that many studies do not have sound rationale for the selection of a particular theory to apply to the study (37). This led to the development of the Theoretical Domains Framework (TDF), which is a theoretical framework designed

for implementation research and, in particular, for the implementation of evidence based practice (37). The TDF was developed based on expert consensus by international health psychology theorists, health services researchers, and health psychologists (without specific expertise in theory, implementation research, or behaviour change) (37). The process to reach consensus on the TDF included several steps. The group of health psychology theorists began by identifying as many psychological theories and theoretical constructs (i.e., the component parts of theories) relevant to the implementation of evidence-based practice as possible. They identified 128 theoretical constructs based on 33 psychological theories related to behaviour change (37). These 128 theoretical constructs were then simplified into theoretical domains (i.e., encompassing a set of similar theoretical constructs) which were evaluated by the health psychology theorists and health services researchers, and validated by the health psychologists, to establish importance (37). Finally, pilot interview questions were generated to aid researchers in identifying potential explanations for the desired behaviour change based on the theoretical domains and constructs (37). This original version of the TDF (TDF-1) included 12 theoretical domains: Knowledge; Skills; Social/professional role and identity; Beliefs about capabilities; Beliefs about consequences; Motivation and goals; Memory, attention, and decision processes; Environmental context and resources; Social influences; Emotion; Behavioural regulation; and Nature of the behaviours (37).

The TDF underwent a content validation exercise with behavioural experts who were unaware of the original TDF (38). This refined version of the TDF (TDF-2) contains 14 theoretical domains covering 84 theoretical constructs with good support for the structure

and content of the domains (38). Although there were less theoretical constructs in the TDF-2, the theoretical constructs were more relevant to behaviour change theory. The 14 domains of the TDF-2 include: Knowledge; Skills; Social/professional role and identity; Beliefs about capabilities; Optimism; Beliefs about consequences; Reinforcement; Intentions; Goals; Memory, attention, and decision processes; Environmental context and resources; Social influences; Emotions; and Behavioural regulation (38). The main changes from the TDF-1 to the TDF-2 are shown in Table 2.1.

Table 2.1: Main differences between the TDF-1 and TDF-2

TDF-1 Theoretical Domains	TDF-2 Theoretical Domains
Beliefs about capabilities	Beliefs about capabilities
	Optimism
Beliefs about consequences	Beliefs about consequences
	Reinforcement
Motivation and goals	Intentions
	Goals
Nature of behaviours	Not applicable – not a theoretical domain in TDF-2

2.4.2 Use of the Theoretical Domains Framework in implementation research

A guide to using the TDF in implementation research was published in 2017 by a group of international researchers (39). Within health behaviour change research, the TDF has been used in a variety of methods, including for studies with a wide range of objectives. A common way the TDF has been applied is in the identification of influences (i.e., barriers and enablers) on the implementation of specific evidence-based behaviours. This can be done quantitatively (e.g., with questionnaires) or qualitatively (e.g., with interviews or focus groups). The TDF can also be used during intervention design, process evaluations, and in the identification of behaviour change techniques. The guide

to conducting TDF-based research includes seven steps: [1] selecting and specifying the target behaviour(s); [2] selecting the study design; [3] developing study materials; [4] deciding the sampling strategy; [5] collecting the data; [6] analysing the data; and [7] reporting findings.

The TDF has been applied to explore factors influencing the imaging behaviours and adherence to diagnostic imaging guideline recommendations (*selecting target behaviours*) among physicians and chiropractors (26, 27, 40). In these qualitative studies (*selecting study design*), interviews or focus groups were conducted (*collecting the data*) with a variety of clinicians who were regularly involved in the management of LBP (*sampling strategy*). An interview guide based on the TDF was used to ask specific questions related to each domain (*developing study materials*). Clinician quotes were coded into the domains of the TDF and specific beliefs or themes within each domain were developed (*analysing the data*) and presented (*reporting findings*).

2.5 Intervention fidelity

2.5.1 Definitions

Fidelity is defined as the degree to which an intervention was implemented as intended by the program developers (41). In the context of intervention fidelity, many terms have been used interchangeably within the literature, including treatment integrity, program integrity, treatment fidelity, intervention fidelity, implementation fidelity, program

fidelity, and adherence (41, 42). This variability reflects how the concept of intervention fidelity has evolved over time. Initially, 'treatment fidelity' referred to 'treatment integrity', which was defined as "the degree to which the treatment was delivered as intended" (43). The term evolved to include 'treatment differentiation', which refers to "whether treatment conditions differ from one another in the intended manner" (44). These initial definitions of intervention fidelity focused solely on the delivery component of the intervention. Subsequent definitions of intervention fidelity incorporated the terms 'treatment receipt' (i.e., "the degree to which the participant understands and demonstrates knowledge of and ability to use treatment skills") and 'treatment enactment' (i.e., "the degree to which the participant applies the skills learned in treatment in their daily life") (33, 45). These definitions include the intervention participant as a component of the intervention fidelity process. Additionally, other researchers consider elements of intervention design and the use of theoretical frameworks as another key component of intervention fidelity (45, 46). While intervention fidelity has been conceptualised in many ways in the literature, within behavioural research, intervention fidelity refers to the "methodological strategies used to monitor and enhance the reliability and validity of behavioural interventions" and the "methodological practices used to ensure that a research study reliably and validly tests a clinical intervention" (45). This conceptualisation of intervention fidelity, developed by the Treatment Fidelity Workgroup of the National Institutes of Health Behavior Change Consortium (NIHBCC) includes five domains which should be considered when addressing intervention fidelity in health behaviour change interventions: study design, provider training, intervention delivery, intervention receipt, and intervention enactment (45). Since this thesis examines

intervention fidelity within behavioural interventions (i.e., interventions targeted at healthcare providers to reduce non-indicated imaging for low back pain), the NIHBCC definition and conceptualisation of intervention fidelity will be used.

2.5.2 National Institutes of Health Behavior Change Consortium (NIHBCC) intervention fidelity framework

The NIHBCC provides a framework for conceptualising and addressing intervention fidelity within health behaviour change studies. It was built upon the model by Lichstein et al. (1994) (33), and includes five domains of intervention fidelity: study design, provider training, intervention delivery, intervention receipt, and intervention enactment (45). Within each domain, the NIHBCC framework provides recommendations on how to report, enhance, and/or assess intervention fidelity.

The domain of study design relates to whether a study can adequately tests its hypotheses in relation to its underlying theory and clinical processes (45). In other words, the intervention should be based on a theoretical framework or clinical guideline and the most relevant independent and dependent variables should be used in the study. Additionally, information about the intervention content and dose should be reported, along with methods to ensure that the intervention and comparison groups are equivalent and potential confounders are addressed (35, 45).

The domain of training aims to ensure that intervention providers are adequately trained to deliver the intervention to the study participants (45). This includes strategies to enhance the training process (e.g., with standardised training sessions or a training manual) and assess the intervention providers' skill acquisition (e.g., with role-playing scenarios, direct observation, or written pre- and post-tests) (35, 45). Assessment of intervention fidelity related to training also continues into the period of intervention delivery, where the providers' skills should be continuously assessed to ensure that no drifting from the protocol occurs and that providers are given the opportunity to maintain their skills (e.g., with booster training sessions) (35, 45).

The domain of intervention delivery aims to enhance and assess intervention providers' ability to deliver the intervention as intended (45). This includes methods used to standardise the intervention delivery (e.g., with an intervention manual or provider checklist), ensure the intervention content and dose are delivered as intended (e.g., with direct observation, video recording, or provider evaluation forms), and assess nonspecific effects from the intervention (e.g., therapeutic alliance) (35, 45).

The domain of intervention receipt focuses on the intervention participant (e.g., patient) and aims to enhance (e.g., with educational handouts or role-play scenarios) and assess (e.g., with post-intervention questionnaires or pre- and post-tests) their understanding and ability to performs skills that were taught during the intervention period (35, 45).

The domain of intervention enactment also focuses on the intervention participant but aims to enhance and assess the participants' ability to use the knowledge and skills gained from the intervention in real-life settings (45). This may involve using methods such as direct observations in real-life settings, participant self-monitoring, and follow-up discussions (35). Although both intervention receipt and intervention enactment are focused on assessing intervention fidelity related to the participant, they differ in that receipt refers to the period of time during the intervention, while enactment refers to the time period after the intervention when the participant should be applying things learned from the intervention in relevant real-life settings.

All five domains of intervention fidelity are important to consider; thus, an important distinction should be made among for what the intervention was designed (study design), what the intervention providers were trained to do (provider training), what was delivered (intervention delivery), what was learned by participants (intervention receipt), and what was actually used by participants (intervention enactment).

A checklist was developed in 2005 by the NIHBCC to assess intervention fidelity within a study across the five domains (35, 47). During the initial development of the checklist, it was used to assess intervention fidelity within health behaviour change studies. These studies included experimental designs (i.e., trials), quasi-experimental designs, and single-group designs since intervention fidelity should be reported within all of these study designs as well (47). The checklist has established face validity and inter-rater reliability (47). The checklist was updated in 2011 to include additional components on

behavioural theory and multicultural considerations (35). This updated checklist contains a total of 40 components for a two-armed trial (44 for three-armed trials and 48 for four-armed trials): 17 (two-armed; 21 for three-armed; 25 for four-armed) in the study design domain; seven in the provider training domain; nine in the intervention delivery domain; five in the intervention receipt domain; and two in the intervention enactment domain (35). Each component is rated as "present", "absent but should be present", and "not applicable" (35). The checklist has been applied in a variety of disciplines to assess the degree to which intervention fidelity has been reported, enhanced, and/or assessed in studies of health behaviour change (48-51).

2.5.3 Importance of intervention fidelity within implementation research

The assessment and evaluation of intervention fidelity at early stages of intervention development, such as during planning and within feasibility studies, can serve as a feedback mechanism to improve the intervention for the main trial (52). For example, assessing intervention fidelity in the early stages of intervention development can provide information on the feasibility of proposed strategies to enhance (e.g., use of treatment manual, frequency of booster sessions) and assess (e.g., direct observation versus audio recording versus checklist) intervention fidelity (53). This can be achieved through interviews or focus groups with potential stakeholders (e.g., clinicians delivering an intervention or participants receiving an intervention) to determine factors that may influence intervention fidelity (53). Doing so can provide an opportunity to develop an

intervention fidelity protocol for the main trial, optimise the intervention, and may influence the targeted outcomes of the intervention.

As new evidence-based interventions are developed, the effect of the implementation of these interventions needs to be assessed. Intervention fidelity is an implementation outcome (41) that is important because it has the potential to moderate the effect of the intervention on the targeted outcomes (54). This means that the results of a study (i.e., the effectiveness or lack of effectiveness) may be attributed to how well an intervention was implemented (34, 45). Significant results from a study may be due to an effective intervention or due to unknown factors added to or omitted from the intervention (35). The belief that an intervention is significant when it is not represents a type I error, and may result in the inappropriate dissemination of an ineffective intervention (35). Similarly, non-significant study results may be due to an ineffective intervention or due to essential components omitted from the intervention (35). The latter is an example of poor intervention fidelity and represents a type II error (i.e., incorrectly believing that an intervention is non-significant) (35). Therefore, the assessment and evaluation of intervention fidelity during a study period is essential for the interpretation of the study's results.

2.6 Proposed intervention to reduce non-indicated imaging for low back pain in Newfoundland and Labrador, Canada

Currently, a large multi-jurisdictional project aiming to reduce non-indicated imaging for LBP funded by the Canadian Institutes of Health Research is underway in Newfoundland and Labrador (NL), Ontario, and Alberta, Canada. As part of the work of the Choosing Wisely Canada Implementation Research Network, one of the aims is to test the effectiveness of a theory-informed intervention to reduce non-indicated imaging for LBP. The intervention will consist of clinician education, a clinician-patient decision aid, and an education booklet with evidence based, patient-specific treatment recommendations.

2.6.1 Local context of Newfoundland and Labrador, Canada

In the province of NL, clinicians who are both able to order x-rays and regularly manage patients with LBP include medical practitioners (e.g., family physicians) and chiropractors (55). Medical practitioners are also able to order CT scans; however, family physicians are unable to order MRIs. As of April 2021, the majority of practicing physicians are located in the Eastern Health Regional Health Authority (69%) and approximately 59% are paid using a fee for service model (56). Additionally, approximately 44% of the practicing physicians in NL are family physicians (56). There are approximately 70 chiropractors in NL, with the majority practising in an urban setting (75%) (57) and paid on a fee-for-service basis only.

The issue of the inappropriate use of imaging in NL, particularly of x-ray and CT, has been documented within the literature. In a medical record review of electronic health records from general practitioners (GPs) in NL, only 6.5% of referrals for lumbar spine

CT imaging were considered appropriate (i.e., concordant with guideline or best practice recommendations) (58). The remaining referrals were either not-concordant with recommendations (16%) or were considered questionable (75.6%), as the referrals did not clearly distinguish between radiating leg pain and true radiculopathy (i.e., with a positive neurological examination) (58). Among chiropractors in NL, a survey on their knowledge of and adherence to radiographic guidelines found that about half of respondents were unaware of or did not know current guideline recommendations for LBP radiography, and one quarter of respondents indicated they did not use guidelines to inform their clinical decisions (57). When adherence was measured using clinical vignettes, adherence ranged from 38-88% for not ordering an x-ray when it was not indicated (27).

2.7 Summary

2.7.1 Research gaps

Although non-specific LBP is common, experienced by many people throughout their lifespan, and represents a high burden to individuals and to society, the pathoanatomical cause of pain is usually undetermined. As such, diagnostic imaging is usually not appropriate for the management of patients with non-specific LBP. However, diagnostic imaging continues to be commonly used in primary care practices. Interventions that have been developed to target the use of non-indicated imaging in primary care have shown varying levels of effectiveness, which may be influenced by a variety of factors, including the lack of intervention fidelity. To date, the reporting of strategies to enhance and assess

intervention fidelity has not been evaluated within studies of interventions targeting physician behaviours to reduce non-indicated imaging for LBP. Developing an understanding of intervention fidelity for these interventions is particularly important to improve the interpretation of the results of studies examining the effectiveness of these interventions. While the TDF has been applied to examine barriers and enablers to clinicians' imaging behaviours, no studies have used the TDF to examine barriers and enablers to enhancing and assessing intervention fidelity for these interventions. Doing so will aid in the accurate development and evaluation of an intervention aimed at reducing non-indicated imaging for LBP in NL, Canada.

2.7.2 Thesis objectives and contribution to the literature

The overall objective of this thesis was to examine strategies that have been or could be used to enhance and/or assess intervention fidelity for interventions aimed at reducing non-indicated imaging for LBP. Two manuscripts have been produced, each focusing on a different aspect of the primary thesis objectives:

I. The first manuscript was a systematic review which aimed to review the literature on interventions targeting physician behaviours to reduce non-indicated imaging for low back pain to [1] examine the reporting of strategies to enhance and/or assess intervention fidelity; [2] report on the psychometric properties of tools used to assess intervention fidelity; and [3] report on the intervention fidelity outcome within evaluations of these interventions.

II. The second manuscript was a qualitative study which aimed to explore perceived barriers and enablers to enhancing fidelity of training and delivery of a proposed theory-informed intervention to reduce non-indicated imaging for LBP by GPs and chiropractors in NL, Canada.

This thesis includes the first systematic review which comprehensively searches and synthesises the literature on the reporting of fidelity within interventions targeting physician behaviours to reduce non-indicated imaging for LBP. The qualitative study will allow for implementation researchers to identify factors which may impact the level of fidelity of the training and delivery of the proposed intervention. Together, strategies used to enhance and/or assess intervention fidelity found in the systematic review and factors affecting fidelity found in the qualitative study may inform the development of an intervention fidelity protocol for the proposed intervention to reduce non-indicated imaging for LBP in NL. The development of an intervention fidelity protocol may enhance fidelity within the main implementation trial, increasing the certainty in the trial results. This thesis provides an in depth understanding of intervention fidelity in relation to interventions aimed at reducing non-indicated imaging for LBP and explores barriers and enablers to enhancing intervention fidelity, specifically to provider training and intervention delivery.

Chapter 3: Fidelity of interventions designed to reduce non-indicated imaging for low back pain: a systematic review

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3.1 Statement of co-authorship

All authors were involved in the design and identification of the research topic and in manuscript preparation. Daphne To completed data extraction, data analysis, data synthesis, the overall interpretation of the data, and wrote the manuscript. Andrea Pike completed data extraction (as the second reviewer), and assisted with data analysis, data synthesis, and the overall interpretation of the data. Amanda Hall and Diana De Carvalho were involved with data synthesis and the overall interpretation of the data. Elaine Toomey was involved in the development of the codebook used for data extraction.

3.2 Abstract

Background: Intervention fidelity refers to whether an intervention was delivered as intended and includes the methodological strategies to enhance and assess this process. Interventions aimed at reducing non-indicated imaging for low back pain (LBP) have shown variable results of effectiveness; however, intervention fidelity has not been previously explored within this context, limiting the interpretation of the findings in these studies.

Objectives: The aim of this systematic review was to review the literature on interventions targeting physician behaviour to reduce non-indicated imaging for LBP in order to: (1) examine the reporting of strategies to enhance and/or assess intervention fidelity; (2) report on the psychometric properties of tools used to measure intervention fidelity; and (3) report on intervention fidelity outcomes within the evaluations of these interventions.

Methods: This review used the search results from a systematic review previously conducted examining behaviour change techniques used in interventions to improve physician adherence to evidence-based LBP imaging and reduce non-indicated imaging for LBP. The National Institutes of Health Behaviour Change Consortium fidelity checklist was used to examine the reporting of intervention fidelity across five domains (study design, provider training, delivery of treatment, treatment receipt, and treatment

enactment). Intervention fidelity scores, psychometric properties of assessment measures, and intervention fidelity outcomes were narratively synthesised.

Results: We identified 27 studies, which included a total of 50 intervention components. At least one strategy to enhance intervention fidelity across the five domains was reported in every intervention component. Strategies were most often used to enhance fidelity to study design or intervention delivery. Strategies to assess intervention fidelity in the intervention components were insufficiently reported. Intervention fidelity was explicitly measured in only four intervention components, with psychometric properties of the measurement methods used only partially reported for only one intervention component.

Conclusion: This is the first study to comprehensively synthesise the literature on the reporting of strategies to enhance and assess intervention fidelity within interventions targeting physicians to reduce non-indicated imaging for LBP. Our review highlights a need for both using and reporting strategies to enhance and assess intervention fidelity to allow for a more appropriate interpretation of results on effectiveness for these interventions.

Registration: 10.17605/OSF.IO/4DYUW

3.3 Introduction

Intervention fidelity refers to the degree to which an intervention is delivered as intended by the intervention developers (47, 59). Within behaviour change research, intervention fidelity also refers to the methodological strategies used to monitor and enhance the

reliability and validity of behavioural interventions (47, 59, 60). This framework for intervention fidelity was developed by the National Institutes of Health Behaviour Change Consortium (NIHBCC) and includes five domains: study design, provider training, intervention/treatment delivery, intervention/treatment receipt, and intervention/treatment enactment (59). Study design relates to whether the study adequately tests its hypothesis in relation to an underlying theoretical framework or mechanism of action. It also relates to having a plan with an *a priori* specification of the dose of the intervention and comparators. Provider training relates to the training process of providers, as well as the enhancement and assessment of the skills and ability of providers to deliver the intervention. Intervention delivery relates to whether the intervention was actually delivered as intended by the intervention developers. Intervention receipt relates to the ability of participants to understand and perform the treatment-related skills during the intervention phase. Intervention enactment relates to the ability of the participants to perform the treatment-related skills in real-life settings.

The NIHBCC developed a fidelity checklist in 2005 to evaluate intervention fidelity across the five domains in studies of health behaviour change research (47). The checklist has established face validity and inter-rater reliability (47), and has been used in a variety of healthcare settings (48-50). The checklist was updated in 2011 to include items on behavioural theory and multi-cultural considerations (60). Within each domain, the NIHBCC fidelity checklist contains strategies to either enhance (e.g., with the use of theory-based interventions and training and intervention manuals) or assess (e.g., with direct observation, audio tapes, self-reported checklists) intervention fidelity (60).

Intervention fidelity is an implementation outcome (61) which has the potential to modulate the effect of the intervention on the targeted outcome (54). This means that the results of a study (i.e., demonstrated effectiveness or lack of effectiveness) may be attributed to how well the intervention was implemented (i.e., the degree to which intervention fidelity was achieved) (59, 62). For example, a study demonstrating non-significant results for an intervention may have been testing a truly ineffective intervention, or the intervention may have been ineffective due to essential components of the intervention being omitted. The latter is an example of poor intervention fidelity which impacted the study results.

Non-specific low back pain (LBP) is a common clinical condition with no pathoanatomical cause of pain (3). Current clinical practice guidelines for the assessment or management of LBP recommend against the use of diagnostic imaging in the absence of red flags for pathology (63, 64), as imaging often does not improve patient outcomes, increases exposure to unnecessary harms, and increases costs to the healthcare system (65-68). Despite this, imaging continues to be commonly used in primary care practices and emergency departments (69, 70). Interventions that have been used to reduce the use of non-indicated imaging include the distribution of educational materials, clinical decision support tools, modified requisition forms, targeted reminders, and audit and feedback (71-74); however, evidence of effectiveness for these interventions has been variable (71-74). To our knowledge, there has been no comprehensive assessment of intervention fidelity within this context. Without knowledge of intervention fidelity, it is

unknown whether the interventions were truly ineffective or if they were ineffective due to poor intervention fidelity.

3.4 Objectives

The aim of this systematic review was to review the literature on interventions designed to change physician behaviour to reduce non-indicated imaging for LBP to: [1] examine and describe the reporting of strategies used to enhance and assess intervention fidelity; [2] report on the psychometric properties of the tools used to measure intervention fidelity; and [3] report on the intervention fidelity outcome within the evaluations of these interventions.

3.5 Methods

A systematic review of the literature was conducted to identify studies of interventions designed to change physician behaviour to reduce non-indicated imaging for LBP. The systematic review was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) 2020 statement (75) (Appendix 1). The protocol for this review was registered prior to the study start on Open Science Framework on May 11, 2021(Appendix 2, 10.17605/OSF.IO/4DYUW).

3.5.1 Data sources and eligibility criteria

This review used the results of a search strategy conducted by our research group that aimed to determine the behaviour change techniques that have been used in interventions to improve physicians' adherence to evidence-based LBP imaging and reduce non-indicated imaging for LBP (76). MEDLINE (OVID), Embase, CINAHL (EBSCO), and the Cochrane Central Register of Controlled Trials were searched from inception to February 2021 (Appendix 3). References from five relevant systematic reviews were hand-searched, and forward (until March 2021) and backward citation tracking of included studies was conducted. Additionally, content experts were consulted to ensure key relevant studies were included. Associated publications for the eligible studies (e.g., published protocols, supplementary files, additional publications) were also retrieved and reviewed.

Studies were eligible for the current review if they were published in English and met the inclusion criteria outlined in Table 3.1. Studies targeting patients or the public directly (e.g., mass media campaigns) and interventions designed to improve adherence to other aspects of LBP guidelines without targeting imaging were excluded. Our current review had additional exclusion criteria. This review only included studies that used an intervention that employed more than just Behaviour Change Techniques '4.1 instruction on how to perform the behaviour' and '9.1 credible source' identified in our previous review (76). There is high quality evidence to suggest that barriers for not ordering imaging for patients with non-specific LBP are multi-factorial and are influenced by factors other than knowledge (77). Consequently, interventions to target this behaviour

require more than simply providing information or instructions on how to perform the behaviour (with or without a credible source). Additionally, protocols, conference abstracts, and intervention development papers were excluded since it was not possible to adequately assess the reporting of intervention fidelity from those publication types.

Table 3.1 Systematic review eligibility (inclusion and exclusion) criteria

Category	Description
Type of Study	Include: • Randomised or cluster randomised trials • Non-randomised controlled trials • Interrupted time-series design • Controlled before-after studies • Uncontrolled before-after studies • Qualitative studies Exclude: • Non-peer reviewed, unpublished studies • Protocols • Conference abstracts • Intervention development papers
Types of Participants	Include: • Studies that aim to change the behaviour of general medical practitioners or emergency department physicians who treat patients with low back pain Exclude: • Studies aiming to change the behaviour of other health care providers (e.g., physiotherapists, chiropractors) using low back pain guidelines • Studies aiming to change the behaviour of general medical practitioners or emergency department physicians treating other patient populations (e.g., arthritis, fibromyalgia, generic chronic pain, neck pain, thoracic spinal pain)

Types of Interventions	Include: • Implementation interventions designed to reduce unnecessary low back pain imaging Exclude: • Implementation interventions that do not directly target general medical practitioners (e.g., mass media campaigns) • Implementation interventions that target the patient specifically • Implementation interventions that only used behaviour change techniques '4.1 instruction on how to perform the behaviour' and '9.1 credible source' as identified in our previous review
Types of Outcome Measures	We did not include inclusion/exclusion criteria based on outcomes

3.5.2 Selection of studies

Eligible studies identified in the previous review (76) were used for this current review. Two reviewers (DT and AP) independently screened full texts to apply the additional exclusion criteria (i.e., studies only providing information or instruction on how to perform the behaviour, protocols, conference abstracts, or intervention development papers). The reviewers met for consensus and any disagreements were resolved by discussion or by consulting a third reviewer (AH).

3.5.3 Data extraction

Two reviewers (DT and AP) independently extracted data on study characteristics from the included studies: author, year, country, study design, and intervention (including intervention components, provider, and dose). The two reviewers also independently extracted data on the psychometric properties (i.e., validity and reliability) and outcomes of intervention fidelity measurements if reported in the study. Authors of studies that

explicitly mentioned that intervention fidelity was measured were contacted for further information if required. If a study did not report any assessment/measurement of intervention fidelity, we assumed they did not assess/measure intervention fidelity and authors were not contacted. Any disagreements in data extraction between the two reviewers were discussed to consensus, with any persisting discrepancies resolved by a third reviewer (ET or AH).

A codebook, adapted from Toomey et al. (50), was developed by one of the authors (DT) to clarify each of the intervention fidelity strategies in the NIHBCC fidelity checklist (Appendix 4). The codebook was reviewed by content experts in intervention fidelity (ET) and implementation science (AH) for completeness and accuracy. Prior to data extraction of the intervention fidelity strategies, two reviewers (DT and AP) pilot tested the codebook. The reviewers met to review extracted data frequently (after every two studies) and discrepancies or disagreements were resolved through discussion to reach consensus. A third reviewer (AH) was available to resolve any disagreements that persisted. This process allowed for the codebook to be reviewed and updated in order to address any confusion with coding of the intervention fidelity strategies used in the studies. This process continued until consensus was reached for 10% of the included studies and no more changes were made to the codebook. One reviewer (DT) extracted data for the remainder of the studies.

Data on intervention fidelity were extracted for each eligible study using the updated NIHBCC fidelity checklist (60) (Table 3.2). The checklist includes a total of 40 strategies

for a two-armed trial (44 for three-armed trials): 17 strategies (two-armed trials; 21 for three-armed trials) in the study design domain; seven strategies in the provider training domain; nine strategies in the intervention delivery domain; five strategies in the intervention receipt domain; and two strategies in the intervention enactment domain (60). Each strategy on the checklist was scored as: "present" (the intervention fidelity strategy was reported), corresponding to a score of 1; "not reported" (the intervention fidelity information was not reported, but should be reported), corresponding to a score of 0; or "not applicable (N/A)" (the intervention fidelity strategy was not applicable) (47). The entire domain on fidelity to provider training was not applicable for interventions where training would not be required (e.g., postal dissemination, automated clinical decision support). The entire domain on fidelity to intervention enactment was not applicable for interventions that were not skills-based. For studies testing multiple-component interventions, data on intervention fidelity was extracted for each intervention component.

Table 3.2 National Institutes of Health Behaviour Change Consortium fidelity checklist (35)

Domain	Component	Present (1); Not reported (0); Not applicable (N/A)
Study Design	1) Provide information about treatment dose in the intervention condition	
	a) Length of contact	
	b) Number of contacts	
	c) Content of treatment	

	d) Duration of contact over time	
	2) Provide information about treatment dose in the comparison condition (1)	
	a) Length of contact	
	b) Number of contacts	
	c) Content of treatment	
	d) Duration of contact over time	
	e) Method to ensure that dose is equivalent between conditions	
	f) Method to ensure that dose is equivalent for participants within conditions	
	2a) Provide information about treatment dose in the comparison condition (2+)	
	a) Length of contact	
	b) Number of contacts	
	c) Content of treatment	
	d) Duration of contact over time	
	3) Specification of provider credentials that are needed	
	4) Theoretical model upon which the intervention is based is clearly articulated	
	a) The active ingredients are specified and incorporated into the intervention	
	b) Use of experts or protocol review group to determine whether the intervention protocol reflects the underlying theoretical model or clinical guidelines	
	c) Plan to ensure that the measures reflect the hypothesized theoretical constructs/mechanisms of action	
	5) Potential confounders that limit the ability to make conclusions at the end of the trial are identified	
	6) Plan to address possible setbacks in implementation (i.e., backup systems or providers)	
	7) If more than one intervention is described, all described equally well	
Provider Training	8) Description of how providers will be trained (manual of training procedures)	
	9) Standardisation of provider training (especially if multiple waves of training are needed for multiple groups of providers)	
	10) Assessment of provider skill acquisition	
	11) Assessment and monitoring of provider skill maintenance over time	
	12) Characteristics being sought in a treatment provider are articulated a priori. Characteristics that should be avoided in a treatment provider are articulated a priori	
	13) At the hiring stage, assessment of whether or not there is a good fit between the provider and the intervention	
	14) There is a training plan that takes into account trainees' different education and experience and learning styles	

Intervention Delivery	15) Method to ensure that the content of the intervention is delivered as specified	
	16) Method to ensure that the dose of the intervention is delivered as specified	
	17) Mechanism to assess if the provider actually adhered to the intervention plan or in the case of computer delivered interventions, method to assess participants' contact with the information	
	18) Assessment of nonspecific treatment effects	
	19) Use of treatment manual	
	20) There is a plan for the assessment of whether or not the active ingredients were delivered	
	21) There is a plan for the assessment of whether or not proscribed components were delivered (e.g., components that are unnecessary or unhelpful)	
	22) There is a plan for how contamination between conditions will be prevented	
	23) There is an a priori specification of treatment fidelity (e.g., providers adhere to delivering >80% of components)	
Intervention Receipt	24) There is an assessment of the degree to which participants understood the intervention	
	25) There are specification of strategies that will be used to improve participant comprehension of the intervention	
	26) The participants' ability to perform the intervention skills will be assessed during the intervention period	
	27) A strategy will be used to improve subject performance of intervention skills during the intervention period	
	28) Multicultural factors considered in the development and delivery of the intervention (e.g., provided in native language; protocol is consistent with the values of the target group)	
Intervention Enactment	29) Participant performance of the intervention skills will be assessed in settings in which the intervention might be applied	
	30) A strategy will be used to improve performance of the intervention skills in settings in which the intervention might be applied	

3.5.4 Data analysis and synthesis

Fidelity strategies on the NIHBCC fidelity checklist were categorised as strategies to either enhance or assess fidelity by the research team, as there is no standard categorisation of this in the literature. The research team came to consensus that the

NIHBCC checklist contained 28 strategies to enhance fidelity and 12 strategies to assess fidelity. The frequency of reporting of strategies to enhance or assess fidelity were reported for each intervention component. For both enhancement and assessment categories, intervention fidelity scores were calculated for each intervention component, stratified by domain, by dividing the number of fidelity strategies "present" by the total number of fidelity strategies deemed "applicable" for that intervention component, multiplied by 100. Intervention fidelity scores were interpreted as "none" (0% reported applicable strategies), "low" (≤50% reported applicable strategies), "moderate" (51%-79% reported applicable strategies), and "high" (≥80% reported applicable strategies) (60, 78). The percentage of reported intervention components using each fidelity strategy was calculated as the number of intervention components with the fidelity strategy "present" as a proportion of the total number of intervention components with the fidelity strategy deemed "applicable". The specific fidelity enhancement and assessment strategies used in the studies were described using a narrative synthesis. For studies explicitly measuring intervention fidelity outcomes, the fidelity outcomes, as well as the psychometric properties (e.g., validity and reliability) of the tools used to measure intervention fidelity were narratively synthesised.

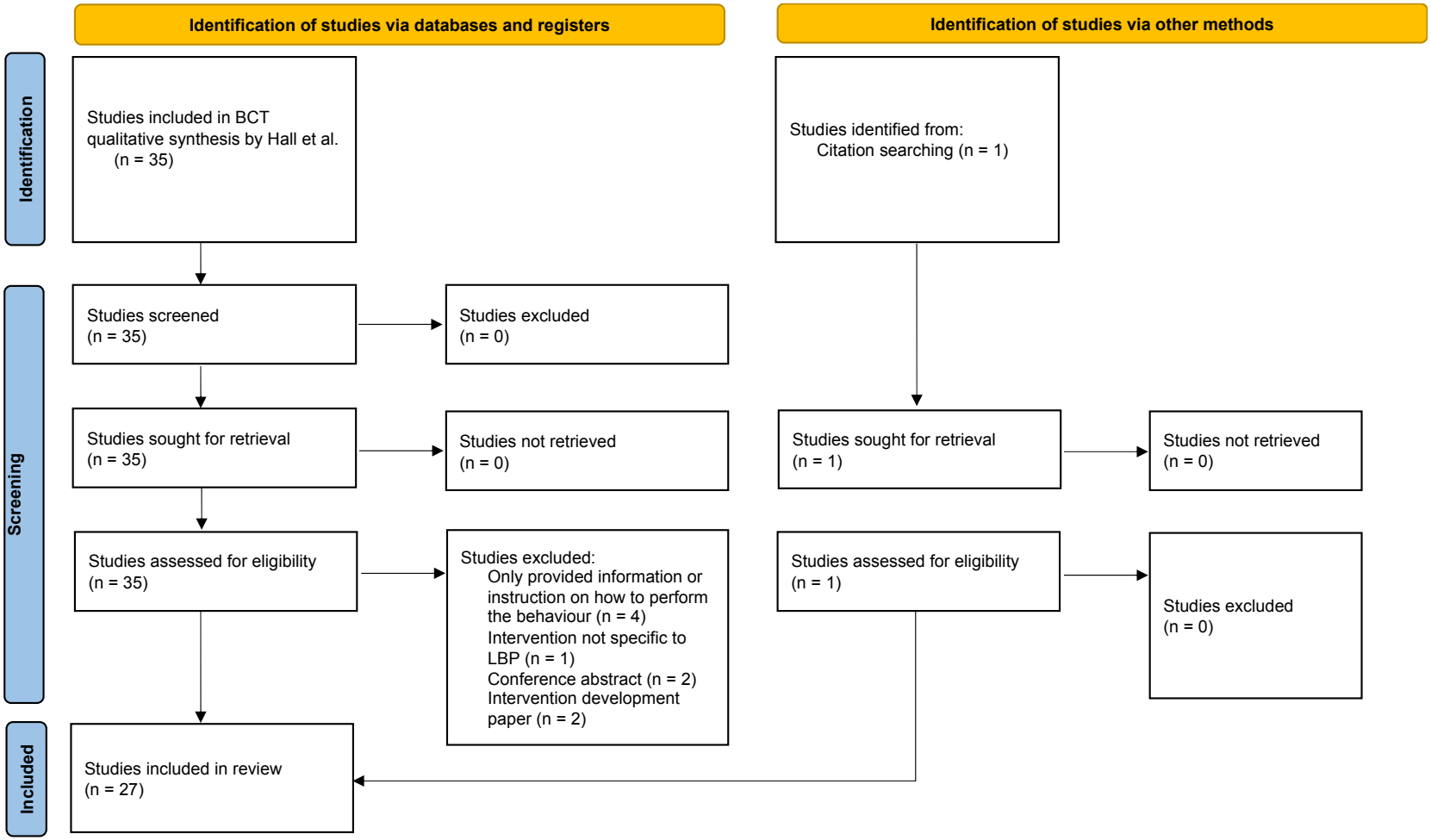
3.5.5 Ethics

Not applicable.

3.6 Results

The systematic review by Hall et al. (76) included 35 eligible studies. Of these, nine did not satisfy our additional intervention eligibility criteria and were excluded. Reasons for exclusion included: study only provided information or instruction on how to perform the behaviour (n=4) (79-82); intervention was not specific to LBP imaging (n=1) (83); conference abstract (n=2) (84, 85); and intervention development paper (n=2) (24, 86). One additional study (87) was identified from the forward citation tracking of an eligible study. Thus, we identified a total of 27 studies testing implementation interventions targeting physician behaviour to improve adherence to evidence-based LBP imaging guidelines by using strategies beyond providing information or instructions on how to perform the behaviour. A description of the study identification based on the search by Hall et al. (76) and the study selection process is outlined in a modified PRISMA flow diagram (Figure 3.1).

Figure 3.1 PRISMA flow diagram



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: http://www.prisma-statement.org/

3.6.1 Description of study characteristics

A description of the study characteristics can be found in Table 3.3. Included studies were published between 1987-2021 and were conducted in the United States (US) (n=15) (87-101), the United Kingdom (UK) (n=6) (102-106), Australia (n=3) (107-109), Canada (n=2) (110, 111), and the Netherlands (n=1) (112). Study designs included randomised controlled trials (RCT)/cluster RCTs (n=11) (88, 94, 96, 98, 102-105, 107, 112), uncontrolled before-after (UBA) (n=9) (90-93, 99, 100, 106, 108, 111), interrupted time-series (ITS) (n=5) (89, 95, 97, 109, 110), and controlled before-after (CBA) (n=2) (87, 101). Data extraction for three studies (107, 109, 112) was supplemented by previously published protocols or additional publications related to the study. Sixteen (59%) of the included studies tested single-component interventions (87-95, 102, 103, 107, 110-112). Eleven (41%) of the included studies tested multiple-component interventions, ranging from 2 to 4 intervention components (96-101, 104-106, 108, 109). A total of 50 intervention components were identified. Intervention components tested in the studies included providing guidelines or other educational material (n=12) (87, 96, 99, 101, 103-106, 108, 109), audit and feedback (n=10) (97, 98, 101, 102, 104-106, 108, 109, 112), education sessions (n=7) (87, 90, 99, 104, 106-108), clinical decision support tools (n=7) (92, 93, 97, 98, 101, 109, 111), change in imaging requisition process (n=4) (95, 100, 102, 106), peer-to-peer consultation (n=3) (97, 99, 100), change in reporting of imaging findings (n= 2) (91, 94), policy change (n=2) (89, 110), training on a specific skill (e.g. delivering patient-centred care) (n=1) (88), precommitment to following a guideline (n=1) (96), and reminders (e.g., for precommitment to following a guideline) (n=1) (96). The

remainder of the results will discuss reporting of fidelity strategies used at the intervention component (n=50) level.

Table 3.3 Study characteristics

Author (year) Country Study design	Intervention: components, provider, dose	Enhancement strategies reported					Assessment strategies reported				
		Design	Training	Delivery	Receipt	Enactment	Design	Training	Delivery	Receipt	Enactment
Single component interventions											
Fine (2017) Canada ITS	*Component*: Policy change. *Provider*: Government. *Dose*: Once.										
Fenton (2016) USA RCT	*Component*: Patient-centred care skill training. *Provider*: Standardised patient instructors. *Dose*: 10 minutes, 1 session.										
French (2013) Australia Cluster RCT	*Component*: Educational workshops. *Provider*: Research team. *Dose*: 2 sessions, 3 hours each.										
Winkens (1995) NL Cluster RCT	*Component*: Audit and feedback. *Provider*: Internal medicine specialist. *Dose*: 5 times over 2.5 years.										
Graves (2018) USA ITS	*Component*: Policy change. *Provider*: Government. *Dose*: Once.										
Robling (2002a) UK Cluster RCT	*Component*: Change in MRI request. *Provider*: Radiology department. *Dose*: Every MRI requisition.										
Robling (2002b)* UK Cluster RCT	*Component*: Seminar guideline dissemination. *Provider*: Study team. *Dose*: Once.										
	Component: Audit and feedback. *Provider*: Study team. *Dose*: Once.										

Author (year) Country Study design	Intervention: components, provider, dose	Enhancement strategies reported					Assessment strategies reported				
		Design	Training	Delivery	Receipt	Enactment	Design	Training	Delivery	Receipt	Enactment
Oakeshott (1994) UK Cluster RCT	*Component*: Postal guideline dissemination. *Provider*: Study team. *Dose*: Once.										
Wang (2018) USA UBA	*Component*: Educational session. *Provider*: Study team. *Dose*: 1 session, 1 hour.										
Wang (2021) USA CBA	*Component*: Guideline dissemination. *Provider*: Study team. *Dose*: Once for continued use.										
	Component: Educational session. *Provider*: Study team. *Dose*: 1 session, 1 hour.										
Fried (2018) USA UBA	*Component*: Epidemiologic statement insertion. *Provider*: Study team. *Dose*: Every imaging report.										
Solberg (2010) USA UBA	*Component*: Electronic decision support system. *Provider*: Electronic health record *Dose*: Every MRI requisition.										
Chen (2020) USA UBA	*Component*: Clinical decision support tool. *Provider*: Electronic medical record. *Dose*: Every imaging requisition.										

Author (year) Country Study design	Intervention: components, provider, dose	Enhancement strategies reported					Assessment strategies reported				
		Design	Training	Delivery	Receipt	Enactment	Design	Training	Delivery	Receipt	Enactment
Jarvik (2020) USA Stepped wedge RCT	*Component*: Epidemiologic statement insertion. *Provider*: Study team. *Dose*: Every imaging report.										
Min (2017)** Canada UBA	*Component*: Clinical decision support tool. *Provider*: Automated through physician order entry system. *Dose*: Every imaging requisition.										
Baker (1987) USA ITS	*Component*: Order form change. *Provider*: Not specified. *Dose*: Every x-ray requisition.										
Multi-component interventions											
Kullgren (2018) USA Stepped wedge cluster RCT	a) *Component*: Precommitment to best practice recommendation. *Provider*: Study team. *Dose*: Once. b) *Component*: Post-it reminder of precommitment. *Provider*: Medical assistants. *Dose*: Every patient with LBP. c) *Component*: Patient education handout. *Provider*: Medical assistants. *Dose*: Every patient with LBP. d) *Component*: Links to resources. *Provider*: Study team. *Dose*: Weekly.										

Author (year) Country Study design	Intervention: components, provider, dose	Enhancement strategies reported					Assessment strategies reported				
		Design	Training	Delivery	Receipt	Enactment	Design	Training	Delivery	Receipt	Enactment
Lin (2016) Australia UBA	a) *Component*: Education workshops. *Provider*: Research team. *Dose*: 2 sessions, 2-3 hours each. b) *Component*: Audit and feedback. *Provider*: Research team. *Dose*: Once. c) *Component*: Clinical tools. *Provider*: Research team. *Dose*: Once.										
Ip (2014) USA ITS	a) *Component*: Real-time clinical decision support. *Provider*: Computerised physician order entry (CPOE) system. *Dose*: Every MRI requisition. b) *Component*: Peer-to-peer telephonic consultation. *Provider*: Radiologist or internist. *Dose*: Each time physician ignored a "not indicated" CDS alert. c) *Component*: Audit and feedback. *Provider*: Research team. *Dose*: Quarterly										

Author (year) Country Study design	Intervention: components, provider, dose	Enhancement strategies reported					Assessment strategies reported				
		Design	Training	Delivery	Receipt	Enactment	Design	Training	Delivery	Receipt	Enactment
Eccles (2001) UK Cluster RCT	a) *Component*: Postal guideline dissemination. *Provider*: GPs and consultant radiologists. *Dose*: Once. PLUS EITHER b) *Component*: Audit and feedback. *Provider*: Research team. *Dose*: Twice. OR b) *Component*: Educational reminder messages. *Provider*: Radiology department. Dose: Every x-ray requisition.										
Kerry (2000) UK Cluster RCT	a) *Component*: Postal guideline dissemination. *Provider*: Study team. *Dose*: Twice. b) *Component*: Audit and feedback. *Provider*: Study team. *Dose*: Once.										

Author (year) Country Study design	Intervention: components, provider, dose	Enhancement strategies reported					Assessment strategies reported				
		Design	Training	Delivery	Receipt	Enactment	Design	Training	Delivery	Receipt	Enactment
Morgan (2019) Australia ITS	a) *Component*: Audit and feedback. *Provider*: Study team. *Dose*: Once. b) *Component*: Symptom self-management prescription pad. *Provider*: National Prescribing Service MedicineWise. *Dose*: Ongoing. c) *Component*: Online decision support tool. *Provider*: Study team in collaboration with research institute. *Dose*: Ongoing.										
Zafar (2019) USA Cluster RCT	a) *Component*: Audit and feedback. *Provider*: Study team. *Dose*: Every 4-6 months for 2 years. b) *Component*: Real-time clinical decision support. *Provider*: Study team. *Dose*: Every MRI requisition for 2 years.										

Author (year) Country Study design	Intervention: components, provider, dose	Enhancement strategies reported					Assessment strategies reported				
		Design	Training	Delivery	Receipt	Enactment	Design	Training	Delivery	Receipt	Enactment
Klein (2000) USA UBA	a) *Component*: Guideline dissemination. *Provider*: Multidisciplinary team of practitioners. *Dose*: Once. b) *Component*: Education sessions. *Provider*: Multidisciplinary team of practitioners. *Dose*: Not specified. c) *Component*: Clinical champion. *Provider*: Rheumatologist. *Dose*: As needed.										
Powell (2019) USA UBA	a) *Component*: Nondenial prior authorisation. *Provider*: Computerised program. *Dose*: Every imaging requisition. b) *Component*: Peer-to-peer consultation. *Provider*: Consulting radiologist. *Dose*: Every imaging requisition when requested by prior authorisation program.										

Author (year) Country Study design	Intervention: components, provider, dose	Enhancement strategies reported					Assessment strategies reported				
		Design	Training	Delivery	Receipt	Enactment	Design	Training	Delivery	Receipt	Enactment
Freeborn (1997) USA CBA	a) *Component*: Postal guideline dissemination. *Provider*: Study team. *Dose*: Once. b) *Component*: Audit and feedback. *Provider*: Study team. *Dose*: Three times. c) *Component*: Clinical decision support tool. *Provider*: Study team. *Dose*: Once.										
Tracey (1994) UK UBA	a) *Component*: Audit and feedback. *Provider*: Study team. *Dose*: Once. b) *Component*: Educational session. *Provider*: Study team. *Dose*: Once. c) *Component*: Guidelines provided. *Provider*: Study team. *Dose*: Once. d) *Component*: Change to radiography request process. *Provider*: Radiology department. *Dose*: Every radiography requisition.										

Author (year) Country Study design	Intervention: components, provider, dose	Enhancement strategies reported					Assessment strategies reported				
		Design	Training	Delivery	Receipt	Enactment	Design	Training	Delivery	Receipt	Enactment

Abbreviations: ITS interrupted time series; RCT randomised controlled trial; UBA uncontrolled before-after; CBA controlled before-after; UK United Kingdom; USA United States of America; NL Netherlands; GP general practitioner; LBP low back pain; MRI magnetic resonance imaging; CDS clinical decision support

Notes: *A third intervention combined the two interventions described in this table. To avoid duplication, this study was considered to test a single component intervention, with the same intervention fidelity components; **Additional educational material described in the study were not considered part of the intervention, as the implementation of those materials were not tested by the study authors.

Legend:

1 or more strategy was reported in the study		No strategy was reported in the study		Strategy was not applicable to the study	

3.6.2 Frequency of strategies to enhance or assess intervention fidelity

After applying the NIHBCC checklist to evaluate the reported use of recommended strategies to enhance or assess fidelity of each intervention component, we found at least one strategy to enhance or assess fidelity was used in all 50 intervention components; therefore, all intervention components were included in the quantitative synthesis of fidelity reporting. A detailed table describing the reporting of all (applicable) strategies to enhance or assess fidelity listed in the NIHBCC checklist for all 50 intervention components can be found in Appendix 5.

3.6.3 Enhancement strategies used

Strategies to enhance fidelity to study design were reported for all intervention components; however, a "high" level of fidelity reporting (i.e., reporting ≥80% of all applicable fidelity strategy items) was found in only 4% (2/50) of intervention components. Of the 17 intervention components where fidelity to provider training was applicable, no strategies to enhance fidelity were reported in 76.5% (13/17) of intervention components, while a "low" level of fidelity reporting (i.e., reporting ≤50% of all applicable fidelity strategy items) was found for the remaining 23.5% (4/17) of intervention components. A "high" level of reporting strategies to enhance fidelity to intervention delivery was found for 22% (11/50) intervention components, while no strategies to enhance fidelity were used in 44% (22/50) of intervention components. No strategies to enhance fidelity to intervention receipt were reported in 74% (37/50) of intervention components, while a "low" level of fidelity reporting was found for 24%

(12/50) of intervention components. Of the five intervention components where fidelity to intervention enactment was applicable, no strategies to enhance fidelity to intervention enactment were reported in any of the intervention components. A summary of the degree to which fidelity enhancement strategies were reported within each domain (ranging from "none" to "high" levels of reporting for an intervention component) is presented in Table 3.4. Examples of strategies used to enhance fidelity to each of the NIHBCC fidelity domains are presented in Table 3.5.

Domain: Study design

This domain has 16 recommended strategies for enhancing intervention fidelity. The recommended enhancement strategies include having an *a priori* specification of the intervention and comparator dose and ensuring that theory or rationale is adequately reflected in the intervention. For the intervention components included in our study, the most commonly reported (>50% of intervention components) enhancement strategies used were: providing an adequate description of the intervention dose (number of contacts (98%), content of intervention (92%), duration of intervention (73%)); providing an adequate description of the comparison intervention dose when applicable (number of contacts (100%), content of intervention (89%), duration of contact (100%), ensuring the dose was equivalent between conditions (100%)); specifying provider credentials required (53%); using measures that reflect the hypothesised theoretical constructs (100%); identifying potential confounders limiting the study conclusions (74%); and describing all interventions completely if there was more than one intervention (71%).

Only four intervention components (8%) (from two studies), specified and incorporated the active ingredients into the intervention.

Domain: Provider training

This domain has four recommended strategies for enhancing fidelity to provider training, the purpose of which is to ensure that the providers of the intervention all receive standardised training. Fidelity to provider training was not applicable for 32/49 (65%) intervention components in our study as there were no components that involved interaction between individuals delivering the intervention and individuals receiving the intervention (e.g., automated electronic interventions, postal guideline dissemination). Provider training was applicable for 17 of the 50 intervention components included in our review; however, enhancement strategies for this domain were only reported in four (24%) intervention components and none of these achieved a "high" level of reporting fidelity strategy use. The most commonly reported enhancement strategy was the standardisation of provider training (e.g., with the use of a training manual); however, this was only reported in 13% of applicable intervention components. A plan that considered differences in education, experiences, and learning styles of trainees was not included in any of the intervention components.

Domain: Intervention delivery

This domain has four recommended strategies for enhancing fidelity to intervention delivery, the purpose of which is to ensure that the intervention content and dose were delivered as intended. At least one of the recommended enhancement strategies was

reported in 16/49 (33%) of the intervention components included in our study. The most commonly reported enhancement strategy was having a plan for how contamination between conditions (e.g., with clustering (85%)) will be prevented. A manual for intervention delivery was reported in only 4/20 (20%) intervention components. A plan to ensure that the dose and content of the intervention were delivered as intended was reported in only 13/50 (26%) and 15/50 (30%) intervention components respectively. A variety of strategies were used to ensure the content of the intervention was delivered as intended, with some strategies built into the design of the intervention (e.g., electronic decision support tools embedded in electronic health records with no option to override delivery, using a manual for delivery), while other strategies were used to monitor how the content was delivered to physicians (e.g., audio recording of physician encounters or in-person meetings with researchers).

Domain: Intervention receipt

This domain has three recommended strategies for enhancing fidelity to intervention receipt, the purpose of which is to ensure that the intervention includes strategies to improve the knowledge and skills of the participant during the intervention session. At least one of the recommended enhancement strategies was reported in 12/49 (24%) intervention components in our review. The most commonly reported enhancement strategy was having a mechanism to improve participant performance of the intervention skills (e.g., with role play or skill rehearsal) during the intervention period (60%); however, this was only applicable to five intervention components which were skills-based. A strategy to improve the participant comprehension of the intervention (e.g., with

opportunities for consultation with peers or the research team, distribution of additional educational material) was reported in only 11/50 (22%) intervention components. Multicultural factors were not reported to be considered in the development and delivery of the intervention for any of the intervention components.

Domain: Intervention enactment

This domain has one recommended strategy for enhancing fidelity to intervention enactment, the purpose of which is to ensure that the intervention includes a strategy to improve the performance of the intervention skills in the settings in which the intervention might be applied. This enhancement strategy only applied to five intervention components included in our review, as they were the only ones which were skills-based. Of the intervention components where this enhancement strategy was applicable, this strategy was not reported in any of the intervention components.

Table 3.4 Frequency of reporting of strategies to enhance or assess fidelity

	Strategies to ENHANCE fidelity				Strategies to ASSESS fidelity			
Fidelity Domain	**None** % of intervention components with **0%** reported applicable strategies	**Low** % of intervention components with **≤50%** reported applicable strategies	**Moderate** % of intervention components with **51-79% reported** applicable strategies	**High** % of intervention components with **≥80%** reported applicable strategies	**None** % of intervention components with **0%** reported applicable strategies	**Low** % of intervention components with **≤50%** reported applicable strategies	**Moderate** % of intervention components with **51-79% reported** applicable strategies	**High** % of intervention components with **≥80%** reported applicable strategies
Design	0/50 0%	15/50 30%	33/50 66%	2/50 4%	44/50 88%	0/50 0%	0/50 0%	6/50 12%
Provider training	13/17 76.5%	4/17 23.5%	0/17 0%	0/17 0%	16/17 94.1%	1/17 5.9%	0/17 0%	0/17 0%
Delivery	22/50 44%	16/50 32%	1/50 2%	11/50 22%	39/50 78%	10/50 20%	1/50 2%	0/50 0%
Receipt	37/50 74%	12/50 24%	1/50 2.0%	0/50 0%	46/50 92%	2/50 4%	0/50 0%	2/50 4%
Enactment	5/5 100%	0/5 0%	0/5 0%	0/5 0%	4/5 80%	0/5 0%	0/5 0%	1/5 20%
Frequency calculated as: Number of intervention components with 0%, ≤50%, 51-79%, or ≥80% reported applicable strategies / Total number of intervention components where the fidelity domain was applicable								

Table 3.5 Examples of strategies to enhance intervention fidelity and proportion of strategies reported within applicable intervention components

	Strategy (Enhance)		Examples of strategies reported within studies
Design	Length of contact (intervention)	5/15	Information regarding intervention dosage was described in the manuscript text in the methods section.
	Number of contacts (intervention)	49/50	
	Duration of contact (intervention)	31/42	
	Content of intervention (intervention)	46/50	Information on the content of the intervention was described in either in the manuscript text (in the methods section), in a supplemental file, additional publication, or previously registered/published protocol.
	Length of contact (comparison)	N/A	No comparison intervention included a component that required a prolonged period of contact.
	Number of contacts (comparison)	9/9	Information on dosage and content of the comparison intervention was described in the text of the manuscript, in the methods section.
	Duration of contact (comparison)	2/2	
	Content of intervention (comparison)	8/9	
	Method to ensure dose is equivalent **between** conditions	N/A	The dosage of the intervention and comparison interventions were not meant to be equivalent for any intervention component.
	Method to ensure dose is equivalent **within** conditions	4/8	This strategy was used in 50% of applicable intervention components (4 studies). The strategies to ensure intervention component dose were delivered as intended varied. For components that involved providing education to physicians, one strategy involved the intervention developers providing an education session script (with timings for each component of the education session) that education session facilitators could use to ensure they delivered all the content at the appropriate dose (88). Another strategy was having a recording of the education session so that physicians who missed the in-person education session received the same education session later (102, 107); however, it was not monitored if the recording was watched. Finally, one strategy was to use an automated approach so that the educational content was automatically included into lumbar spine imaging reports, ensuring that those who ordered imaging always received the educational content (94).
	Specification of provider credentials that are needed	9/17	This strategy was used in 53% of applicable intervention components and was described in the text of the manuscript (in the methods section). The credentials that were needed were only related to professional background of the intervention providers (e.g., general practitioner, radiologist, allied health

			clinical backgrounds) and no further credentials were provided (e.g., special training, years of experience, etc.) (96, 97, 100, 102, 104, 107, 112).
	The active ingredients are specified and incorporated into the intervention	4/50	This strategy was used in 8% of intervention components (2 studies). This strategy required the use of a theoretical model to underpin the selection/choice of intervention components. The two studies that employed this strategy (107, 108) both included a table linking the theory to the intervention component; however, neither included a logic model which would be best practice for this strategy. Although not supported by theory, in 17 studies (representing 24 intervention components), the choice of intervention components was supported with evidence from previous literature (87, 88, 91-94, 96, 98, 102, 104, 109, 111, 112). The rationale for including one intervention component was based on the clinical experiences of the intervention developer (99). A change in government policy was the rationale for using one intervention component which tested a change in policy (89). Additionally, the authors of 3 studies (representing 5 intervention components) provided only a hypothesis, without supporting rationale (90, 103, 109).
	Plan to ensure that the measures reflect the hypothesised theoretical constructs/mechanisms of action	4/4	This strategy was deemed only applicable when the interventions were based on theory or the mechanisms of action were specified. In this case, the strategy was used in 100% of intervention components (2 studies). In both studies, the mechanisms of action as well as resulting clinical outcomes were planned to be measured at the physician-level, with one study using questionnaires (107) and another study using qualitative interviews (108).
	Potential confounders that limit the ability to make conclusions at the end of the trial are identified	11/31	This strategy was used in 36% of applicable intervention components (6 studies). In these studies, confounders such as demographic differences were adjusted for in the statistical analysis (89, 91, 97, 100, 109, 110). In 7 studies (representing 12 intervention components), factors limiting the conclusions of the results were identified in the discussion section of the manuscript (87, 90, 92, 93, 101, 108, 111).
	Plan to address possible setbacks in implementation	2/48	This strategy was only used in 4% of the intervention components and was only used to address setbacks in provider training. In the two intervention

			components where this strategy was used, audio or video recordings were available if providers could not attend the in-person training session (99, 107).
	If more than one intervention is described, all described equally well	5/7	Information on the intervention and comparison intervention dosages were described in the same level of detail in the text of the manuscript (in the methods section).
Training	Description of how providers will be trained	2/17	These strategies were only used in 12% of intervention components (1 study) where provider training was applicable. In this study, a description of provider training was provided in the methods section of the manuscript, describing the role of the intervention provider (i.e., the medical assistants in this study) and the training session that was provided to them. To standardize the training dose/timing and content, a training manual was used (and provided as a supplementary file) (96).
	Standardisation of provider training	2/17	
	Characteristics being sought in a treatment provider are articulated a priori. Characteristics that should be avoided in a treatment provider are articulated a priori.	2/17	This strategy was only used in 12% of the intervention components where provider training was applicable. In the two intervention components where this strategy was used, the professions of the intervention providers required were described in the text of the manuscript, primarily in the methods section (107, 112).
	There is a training plan that takes into account trainees' different education and experience and learning styles	0/17	This strategy was not reported in any of the studies where provider training was used.
Delivery	Method to ensure content of the intervention is delivered as specified	15/50	This strategy was used in 30% of intervention components (12 studies); however, there was a wide range of strategies used. First, there were strategies built into the design of the component itself. These strategies included having a standardised set of materials with specific content and instructions that providers could use when delivering intervention training to physicians (107) or by providing the intervention content in a standardised educational material that was provided to physicians via the study website (109) or during an initial study consultation (96). Additionally, for those components that involved a decision support tool, the tool was either embedded within the electronic image ordering system or information on when to order imaging was added to the existing paper image order form. In these studies, the content was designed to always be delivered in a standardised way at the time of ordering (92, 93, 95, 97, 98, 100). Second, there were strategies that involved the research team monitoring how

		the intervention content was delivered to physicians via audio-recording training sessions and providing feedback to providers about content delivery (88), in-person meetings with physicians to see if they had received the content (101), or checking imaging reports (via text matching) to ensure the new intervention content was embedded into report as intended (94).
	Method to ensure dose of the intervention is delivered as specified 13/50	This strategy was used in 26% of intervention components (11 studies). Four studies used an electronic decision support tool with automated delivery of the tool to ensure the dose of the tool was always delivered through the electronic medical record, with no option to override the decision support tool (92, 93, 98, 100). One study used an automated process to ensure that an epidemiologic statement was always inserted on each imaging report (94). One study which included a communication skills training session used audio recording of the training sessions, which were then reviewed by the research team to ensure the correct dose and content of the sessions were delivered as intended (88). Different forms of reminders were used by 2 studies. In one study, which had an education session for physicians, a detailed session plan with timing and content information was used to help (and act as a reminder for) the education session providers to deliver the session as intended (107). In another study testing new imaging requisition forms with restricted indications for imaging, physicians were strongly encouraged to use the new imaging requisition form (acting as a reminder) to ensure the appropriate delivery of the intervention (i.e., for every imaging requisition) (95). Another strategy used by 2 studies to ensure the dose of the intervention was delivered as specified was monitoring. In one study, the rates of educational message attachment to imaging reports were checked (104), and in another study involving the delivery of guidelines and feedback, questionnaires were sent to the physicians to ensure the intervention was delivered as intended (101). In one intervention component which used precommitment to use the intervention, signing the precommitment form was enough to ensure the dose of the intervention (i.e., precommitment information) was delivered (96).
	Use of treatment manual 4/20	This strategy was used in 20% of applicable intervention components (2 studies). In both studies where this strategy was applicable, the treatment manual was provided in an additional study (107) or supplementary file (96).

	There is a plan for how contamination between conditions will be prevented	18/21	This strategy was used in 86% of applicable intervention components (11 studies). In eight randomised controlled trials, the most common method used to prevent contamination between conditions was to use clustering in the study design (94, 98, 102-105, 107, 112). Clustering was also used in one controlled before-after study (101). In an uncontrolled before-after study, the study period was selected to avoid the preparation or acclimatization periods immediately before or after the implementation of the intervention (92).
Receipt	There are specification of strategies that will be used to improve participant comprehension of the intervention	11/50	This strategy was used in 22% of intervention components (9 studies). The strategy most commonly used to improve physician comprehension of the intervention was to provide an opportunity for consultations with peers or the research team (97, 100, 101). In 2 studies using education sessions, question and answer sessions were held at the end of education session to improve physician comprehension (102, 107). For some intervention components consisting of electronic clinical decision supports, educational material on current guidelines was provided to physicians to increase their understanding of why imaging should not be ordered (98, 111). For an audit and feedback intervention component, educational messages and points for reflection based on clinical guidelines and current evidence were provided as part of the feedback (109). In another audit and feedback intervention component, questions related to the feedback were encouraged (102). In a guideline dissemination intervention component, a summary was provided to preface the guideline (99).
	A strategy will be used to improve subject performance of intervention skills during the intervention period	3/5	This strategy was only applicable to skills-based intervention components and was used in 60% of these types of intervention components. Within these intervention components, participants were able to practice skills through role play (88), skill rehearsal (108), and simulated patient scenarios (107).
	Multicultural factors considered in the development and delivery of the intervention (e.g., provided in native language; protocol is consistent with the values of the target group)	0/50	This strategy was not used in any intervention components.

Enactment	A strategy will be used to improve performance of the intervention skills in settings in which the intervention might be applied 0/5	This strategy was not used in any intervention components where intervention enactment was applicable.

Legend
Strategy reported in 0% of intervention components
Strategy reported in ≤50% of intervention components
Strategy reported in 51-79% of intervention components
Strategy reported in ≥80% of intervention components
Strategy not applicable to any intervention components

3.6.4 Assessment strategies used

No strategies to assess fidelity to study design were reported in most intervention components (88%, 44/50), while "high" level of fidelity reporting was found for the remaining 12% (6/50) of intervention components. Of the 17 intervention components where fidelity to provider training was applicable, no strategies to assess fidelity were reported in 94.1% (16/17) of intervention components. No strategies to assess fidelity to intervention delivery were reported in 78% (39/50) of intervention components, while a "low" level of fidelity reporting was found for 20% (10/50) of intervention components. No strategies to assess fidelity to intervention receipt were reported in 92% (46/50) of intervention components, while a "high" level of fidelity reporting was found in only 4% (2/50) of intervention components. Of the five intervention components where fidelity to intervention enactment was applicable, no strategies to assess fidelity were reported in 80% (4/5) of intervention components, while a "high" level of fidelity reporting was found in 20% (1/5) of intervention components. A summary of the degree to which fidelity assessment strategies were reported within each domain (ranging from "None" reported to "high" levels of reporting for an intervention component) is presented in Table 3.4. Examples of strategies used to assess fidelity to each of the NIHBCC fidelity domains are presented in Table 3.6.

Domain: Study design

The domain has one recommended strategy for assessing intervention fidelity – using experts or protocol review groups to determine if the intervention protocol reflected the

underlying theoretical model. This assessment strategy was reported in only 6/49 (12%) intervention components.

Domain: Provider training

This domain has three recommended strategies for assessing fidelity to provider training, the purpose of which is to assess if providers have been adequately trained in delivering the intervention. Provider training was applicable for 17 of the 50 intervention components included in our review; however, assessment strategies for this domain were reported in only one (6%) intervention component (assessing and monitoring provider skill maintenance over time).

Domain: Intervention delivery

This domain has five recommended strategies for assessing fidelity to intervention delivery, the purpose of which is to assess if providers actually delivered the intervention as planned. At least one of the recommended assessment strategies was reported in 22/49 (45%) intervention components. The most commonly reported assessment strategy was having a mechanism to assess if the provider actually adhered to the intervention plan (e.g., with audio recordings or self-reported checklists), or for computer delivered interventions, a method to assess participants' contact with the information (e.g., using automation to ensure the intervention was always delivered). However, this was only reported in 18.37% of intervention components. A plan for the assessment of whether or not proscribed components (e.g., components that are unnecessary or unhelpful) were

delivered was not reported in any intervention components, nor was an *a priori* specification of intervention fidelity reported in any intervention components.

Domain: Intervention receipt

This domain has two recommended strategies for assessing fidelity to intervention receipt, the purpose of which is to ensure that the intervention includes strategies to assess the knowledge and skills of the participants during the intervention session. At least one of the recommended assessment strategies was reported in only 4/49 (8%) intervention components (having an assessment of the degree to which participants understood the intervention). For the five intervention components which were skills-based intervention components, the ability of the participant to perform the intervention skills during the intervention period was not reported to be assessed in any of the intervention components.

Domain: Intervention enactment

This domain has one recommended strategy for assessing fidelity to intervention enactment, the purpose of which is to assess participant performance of the intervention skills in the settings in which the intervention might be applied. This assessment strategy only applied to five intervention components, as they were the only ones which were skills-based and was reported in only one intervention component.

Table 3.6 Examples of strategies to assess intervention fidelity and proportion of strategies reported within applicable intervention components

	Strategy (Assess)		Examples of strategies reported within studies
Design	Use of experts or protocol review group to determine whether the intervention protocol reflects the underlying theoretical model or clinical guidelines	6/50	This strategy was used in 12% of intervention components (6 studies), in a variety of ways. The intervention developers of two studies validated their intervention with experts or end users (109, 112). Where theory was used to inform the intervention, an expert group was used to determine which behaviour change techniques should be chosen and to check if the proposed content was likely relevant and helpful (107). An expert group was used in another intervention to confirm the problem definition and appropriateness of the intervention (111). Key informant interviews were conducted to assess and refine the intervention (88). In a study assessing a policy change, a government department was used to determine the appropriateness of the intervention (89).
Training	Assessment of provider skill acquisition	0/17	This strategy was not reported in any of the studies where provider training was applicable.
	Assessment and monitoring of provider skill maintenance over time	1/16	This strategy was only used in 6% of intervention components (1 study) where provider training was applicable. In a skills training program, corrective feedback was provided to instructors after intervention developers listened to audio recordings from the training program (88).
	At the hiring stage, assessment of whether or not there is a good fit between the provider and the intervention	0/12	This strategy was not reported in any of the studies where provider training was applicable.
Delivery	Mechanism to assess if the provider actually adhered to the intervention plan or in the case of computer delivered interventions, method to assess participants' contact with the information	10/50	This strategy was used in 20% of intervention components (8 studies). Audio recordings or self-reported checklists of the intervention sessions were used in two studies to assess if the intervention was delivered as intended (88, 107). In some studies, where education or information was provided, questionnaires were used to assess if participants

			remembered receiving the intervention (101, 105). For one intervention using an electronic clinical decision support tool, information on the number of times physicians were overriding the decision support tool and their rationale for overriding the clinical decision support tool was collected (93). For another intervention using an automated electronic decision support tool, the automated process was created in a way where physicians would always have contact with the information (97). In an intervention where the imaging requisition order form was changed, the rate of non-compliance to using the form was measured (95). In one intervention component which used precommitment to use the intervention, signing the precommitment form was enough to assess the participants' contact with the information (i.e., precommitment information) (96).
	Assessment of nonspecific treatment effects	2/15	This strategy was used in 13% of applicable intervention components. In both intervention components where this strategy was used, audio recordings of the intervention sessions were used (88, 107).
	There is a plan for the assessment of whether or not the active ingredients were delivered	2/50	This strategy was only used in 4% of intervention components (2 studies). One study assessed both the observed adherence to planned behaviour change techniques delivery and the variation in delivery of the behaviour change techniques across different facilitators and sessions (107). In another study, the electronic system inputting intervention text to imaging reports was queried with text matching to ensure that the imaging reports contained the correct text (94).
	There is a plan for the assessment of whether or not proscribed components were delivered (e.g., components that are unnecessary or unhelpful)	0/50	This strategy was not used in any intervention components.
	There is an a priori specification of intervention fidelity	0/50	This strategy was not used in any intervention components.

Receipt	There is an assessment of the degree to which participants understood the intervention	4/49	This strategy was only used in 8% of applicable intervention components (2 studies). In an intervention consisting of an educational session, there were pre- and post-workshop questions based on the content of the intervention (107). In another multi-component intervention, interviews with participants were conducted where they were asked to reflect on the intervention strategies used, and to report whether any changes had occurred as a result of the intervention (108).
	The participants' ability to perform the intervention skills will be assessed during the intervention period	0/5	This strategy was not used in any of the skills-based intervention components.
Enactment	Participant performance of the intervention skills will be assessed in settings in which the intervention might be applied	1/5	This strategy was only applicable to skills-based intervention components and was used in 20% of intervention components. In a skills training program, standardised patient encounters were completed after the training program to assess whether the study physicians continued to practice the skills they learned from the training program (88).

Legend
Strategy reported in 0% of intervention components
Strategy reported in ≤50% of intervention components
Strategy reported in 51-79% of intervention components
Strategy reported in ≥80% of intervention components
Strategy not applicable to any intervention components

3.6.5 Outcomes of intervention fidelity measurement

Intervention fidelity outcomes, all within the NIHBCC domain of intervention delivery (Table 3.7), were reported in four intervention components (from four studies). No measurement of intervention fidelity was reported in the other four domains in any study. Eccles et al. (104) reported checking rates of message attachments for educational reminder messages as a method to ensure that the dose of the intervention was delivered as specified. The authors reported that the rate of attachment was almost 100% when educational reminder messages were attached electronically or by hand, but only 40% when an operator had to press a key to add the message. Kerry et al. (105) reported using a postal questionnaire to see if physicians remembered receiving guidelines which were distributed by post as a mechanism to assess physicians' contact with the information. The authors reported that 92% of the physicians remembered receiving the guidelines. French et al. (107, 113) used audio recorded workshops and facilitator self-reported checklists at the end of an educational workshop to assess if the active ingredients of the intervention were delivered. The authors concluded that the observed adherence to the planned behaviour change techniques across all workshops was 79%, ranging from 33% to 100% per session. Fenton et al. (88) reported using a checklist during a skills training session in order to assess if the providers actually adhered to the intervention plan and to assess if the active ingredients were delivered; however, no fidelity outcomes were reported and the authors did not respond to a request for further clarification.

Psychometric properties of intervention fidelity measurement

Only one study (French et al. (107, 113)) partially reported psychometric properties for their fidelity assessment. Observed adherence to the planned behaviour change techniques was assessed using audio recorded workshops transcribed verbatim and initially coded independently by two researchers. Coding results were discussed until agreement of at least 80% was established on the occurrence of the behaviour change techniques. One researcher coded remaining transcripts and a random check of 10% of the remaining coding was undertaken by the second researcher. At least 80% agreement on the occurrence of behaviour change techniques had to be confirmed. When comparing the self-reported adherence using checklists to the gold standard of observed adherence with audio recording the following parameters were determined: the sensitivity was 95% (95% CI 88%-98%), the specificity was 30% (95% CI 11%-60%), the positive predictive value of self-reported adherence was 92% (95% CI 84%-96%), and the negative predictive value was 43% (95% CI 16%-75%). The authors concluded that the workshop facilitators were able to accurately determine if a section of the workshop was delivered, but were less able to accurately determine if a section was not delivered.

Table 3.7 Outcomes and psychometric properties of intervention fidelity assessments/measures

Author (year); Intervention component	**NIHBCC domain and fidelity strategy**	**Assessment strategy/measurement used**	**Reported validity**	**Reported reliability**	**Fidelity outcome**
Eccles (2001) Educational messages	Delivery – Method to ensure that the dose of the intervention is delivered as specified	Rates of message attachment checked regularly	Not reported	Not reported	Attachment rate of was close to 100%, or was 100%, in departments where messages were attached electronically. Attachment rate was 100% in departments where messages were attached by hand. Attachment rate was around 40% in departments where an operator pressed a key to add the message.
Kerry (2000) Guideline dissemination	Delivery – Mechanism to assess if the provider actually adhered to the intervention plan or in the case of computer delivered interventions, method to assess participants' contact	Postal questionnaire to explore doctors' attitudes to the guidelines	Not reported	Not reported	92% of general practitioners remembered receiving the guidelines

	with the information				
French (2013) Educational workshop	Delivery – There is a plan for the assessment of whether or not the active ingredients were delivered	Audio recorded workshops transcribed verbatim	Not reported	Agreement of at least 80% was established on the occurrence of behaviour change techniques and the relevant text for each workshop	Observed adherence to planned behaviour change techniques across all workshops was 79% overall, ranging from 33% to 100% per session.
		Facilitator self-reported checklist completed at the end of the workshop	Sensitivity of self-reported adherence (facilitators correctly identifying when a section of a workshop did occur according to the 'gold standard' of observed adherence): 95% (95% CI 88 to 98); Specificity (ability of the facilitators to correctly identify when a section of a workshop did not occur according to the observed adherence): 30% (95% CI 11 to 60). Positive predictive value of self-reported adherence:	Not reported	

			92% (95% CI 84 to 96); Negative predictive value: 43% (95% CI 16 to 75).		
Fenton (2016) Training session	Delivery – Mechanism to assess if the provider actually adhered to the intervention plan or in the case of computer delivered interventions, method to assess participants' contact with the information	Using standard checklists, a standard patient supervisor prospectively monitored fidelity by listening to audio recordings of selected standardised patient instructor and standardised patient visits, assessing role fidelity using a checklist	Not reported	Not reported	Not reported (author could not be contacted)

3.7 Discussion

This is the first review to comprehensively search the literature on the reporting of intervention fidelity within studies of interventions designed to change physician behaviour in reducing non-indicated imaging for LBP. We found 27 studies, with a total of 50 intervention components, used to target physician behaviour to reduce non-indicated imaging for LBP. Commonly used intervention components included providing guidelines or other educational materials, audit and feedback, education sessions, and clinical decision support tools. While all studies reported using at least one strategy to enhance fidelity, most used less than 50% of the recommended strategies. The strategies reported most often were those to enhance fidelity to the study design (i.e., to ensure the observed effects for reducing non-indicated imaging could be attributable to the intervention) or to the delivery of the intervention (i.e., content and dose were delivered to the physicians as intended). The use of strategies to enhance if physicians actually received the intervention were rarely reported, and the use of strategies to enhance if they enacted the intervention skills in practice were never reported. The use of strategies to assess fidelity were reported infrequently across all domains, with the use of very few strategies reported in the domains of assessing fidelity to study design, provider training, or intervention receipt. Most of the assessment strategies identified were to assess fidelity to intervention delivery or enactment. Intervention fidelity was only explicitly measured within four intervention components, with three providing results on the assessments, and only one partially reporting on the psychometric properties of tools used to assess

intervention fidelity. Thus, while there seems to be some attention being paid to incorporate strategies to enhance intervention fidelity, there is much less attention paid to the assessment of fidelity and the use of valid or reliable methods to measure intervention fidelity.

Strategies to enhance fidelity to study design were reported for most intervention components. A plan to ensure that the content and dose of interventions (and comparators if applicable) were clearly defined was included in most intervention components, which may impact how successful complex behaviour change interventions are introduced and scaled up (114). While most intervention developers had a rationale for testing the intervention components used in their studies, only two intervention components (from French et al. (107) and Lin et al. (108)) were based on theory. This indicates that most interventions that have been used to reduce non-indicated imaging for LBP have not been based on theoretical mechanisms of change. This may limit our ability to identify intervention components which are causally related to behaviours which would reduce non-indicated imaging for LBP (114).

Strategies to enhance or assess fidelity in all other domains (i.e., provider training, intervention delivery, intervention receipt, and intervention enactment) were insufficiently reported. It is unknown if the providers delivering the intervention components to physicians to reduce non-indicated imaging for LBP were adequately trained. Previous research demonstrates that ensuring providers have the appropriate knowledge and expertise, together with strategies to enhance provider training (e.g., with

manuals), leads to higher rates of implementation success (115-117). With few or no strategies to enhance or assess fidelity to intervention delivery, receipt, and enactment in most studies, we are unsure if the intervention components were actually delivered and/or received by the physicians in these studies.

3.7.1 Findings in context with existing literature

Two previous reviews on the effectiveness of interventions to reduce non-indicated imaging, one for musculoskeletal conditions (28), and another for LBP in emergency care settings (73), found that information on intervention fidelity was rarely reported. When details on intervention fidelity were reported, it was usually only partially reported, reported for some domains of intervention fidelity (primarily intervention delivery), and did not describe how intervention fidelity was assessed. Since then, many new studies have been conducted on interventions to reduce non-indicated imaging for LBP, particularly in primary care settings. Based on the findings from our current systematic review, which used the NIHBCC fidelity framework to examine the reporting of intervention fidelity within these studies, many studies are still inadequately reporting the use of strategies to enhance intervention fidelity (if reported, mostly for fidelity to study design or intervention delivery) and most studies are still not reporting on strategies to assess intervention fidelity.

The psychometric properties of methods used to actually measure intervention fidelity have previously been synthesised for complex, face-to-face health behaviour change

interventions (118). While the majority of studies did not report whether the measure used was developed on their own or previously developed, the majority of studies reported at least one psychometric property (i.e., related to validity or reliability). This finding contrasts with the findings of our review, as our review found that few studies actually measured intervention fidelity and only one study partially reported on the psychometric properties of the measurement tools used.

3.7.2 Strengths

Our analysis was guided by the widely used NIHBCC fidelity framework, as well as the validated NIHBCC fidelity checklist. We developed a codebook to use the NIHBCC fidelity checklist with a content expert who had experience in applying this checklist for other complex health behaviour change interventions. We also further developed the codebook with an iterative process, detailing all coding assumptions and rules as they related to the context of our studies and intervention components. This ensured consistency between coders during the initial 10% of studies, and ensured that the single coder for the remaining studies was able to consistently apply the coding assumptions and rules.

3.7.3 Limitations

While the search strategy used in the previous review by Hall et al. (76) was comprehensive, we did identify one study from hand-searching the reference lists. Therefore, it is possible that studies may have been missed by our search. The original

search was completed in 2021 and included protocol papers which may have now been published; therefore, an update of the search may be necessary. In the original NIHBCC fidelity checklist, study designs had to contain an experimental manipulation of treatment, although single-group designs and quasi-experimental designs were also included (47). The original NIHBCC fidelity checklist excluded interventions which focused on policy when it was developed and tested; however, we believe that intervention fidelity should also be reported for the implementation of policy interventions, so these were included in our review. When applying the NIHBCC fidelity checklist to these policy interventions, it is possible that certain items were coded in a way that was more conservative than intended by the developers of the NIHBCC fidelity checklist. Therefore, it is possible that we underestimated the reporting of strategies to enhance or assess intervention fidelity. When interpreting intervention fidelity scores, the cut-off categories used (e.g., "none" as 0% reported applicable strategies, "low" as ≤50% reported applicable strategies, "moderate" as 51%-79% reported applicable strategies, and "high" as ≥80% reported applicable strategies) are based on previous literature (78) but are also somewhat arbitrary. However, these cut-offs are helpful in synthesising literature and may be helpful in comparing to previous or future literature on this topic. Our study only examined the reporting of strategies to enhance and assess intervention fidelity and not the actual use of strategies to enhance and assess intervention fidelity. While we tried to access any protocols, supplementary files, or additional publications mentioned in the primary study, we were unable to contact study authors for further clarification on the use of strategies to enhance and assess intervention fidelity.

3.7.4 Implications for research

Our study highlights the need for the reporting of strategies to enhance and assess intervention fidelity in the development of future interventions targeting physician behaviours to reduce non-indicated imaging for LBP. This review provides intervention developers with an overview of some strategies that have been used in other studies to enhance and assess intervention fidelity across the five intervention fidelity domains. Future research should also aim to determine which enhancement or assessment strategies are the most appropriate for certain types of interventions. Stakeholders involved in policy, funding, and health services research should also consider whether intervention fidelity was adequately reported and/or assessed as part of their decision-making process on whether or not an intervention should be implemented.

Intervention fidelity has been recognised by various reporting guidelines as an important implementation outcome that plays a role in the interpretation of trial results (119, 120). Our review demonstrates that there has been poor reporting of strategies to enhance and assess intervention fidelity overall. Previous systematic reviews on the effectiveness of interventions to reduce non-indicated imaging for LBP have shown variable results of effectiveness (71-74). This suggests there may be an association between the use of strategies to enhance and assess intervention fidelity and the effectiveness of those interventions, which could be further explored.

Our review also highlighted that intervention fidelity has rarely been measured within studies targeting physician behaviours to reduce non-indicated imaging for LBP, and in

the studies that did report on intervention fidelity, they were all within the domain of fidelity to study design. Further, the psychometric properties of the measurement tools used are largely unknown. Future studies should explore the psychometric properties of measurement tools for intervention fidelity and apply these measurement tools across all five intervention fidelity domains.

3.8 Conclusion

We conducted the first systematic review synthesising the reporting of intervention fidelity within studies of interventions targeting physician behaviours to reduce non-indicated imaging for LBP. We found that of the 50 intervention components included in our review, most reported using either no strategies or few strategies to enhance or assess intervention fidelity within each of the five domains (study design, provider training, intervention delivery, intervention receipt, and intervention enactment). Intervention fidelity was only explicitly measured in four intervention components, with the psychometric properties of the assessment methods used only partially reported for one intervention component. This review highlights the need for increased use and reporting of strategies to enhance and assess intervention fidelity within future interventions developed to target physician behaviours to reduce non-indicated imaging for LBP. This will allow for a more complete interpretation of the effectiveness of these interventions.

Chapter 4: Exploring perceived barriers and enablers to fidelity of training and delivery for an intervention to reduce non-indicated imaging for low back pain: a qualitative interview study

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4.1 Statement of co-authorship

All authors were involved in the design and identification of the research topic and in manuscript preparation. Daphne To developed the interview guide and codebook for analysis, conducted the interviews, and lead the data analysis. Andrea Pike assisted with conducting the interviews, data analysis, and the overall interpretation of the data.

Rebecca Lawrence assisted with coding of the interviews. Holly Etchegary reviewed the interview guide. Andrea Patey reviewed the codebook for analysis. Elaine Toomey reviewed the interview guide and codebook for analysis. Amanda Hall and Diana De Carvalho were involved with the overall interpretation of the data.

4.2 Abstract

Background: Non-specific low back pain (LBP) is a common condition presenting to primary care, where the inappropriate use of imaging for LBP remains common despite guideline recommendations against its routine use. Little is known about strategies to enhance intervention fidelity (i.e., whether interventions were implemented as intended) for interventions that have been developed to reduce non-indicated imaging for LBP. *Objectives*: To inform the development of an intervention to reduce non-indicated imaging among general practitioners (GP) and chiropractors in Newfoundland and Labrador, Canada, this study has two objectives: [1] To explore perceived barriers and enablers to enhancing *fidelity of training* of GPs and chiropractors to deliver a proposed intervention aimed at reducing non-indicated imaging for LBP and [2] To explore perceived barriers and enablers to enhancing *fidelity of delivery* of a proposed intervention aimed at reducing non-indicated imaging for LBP by GPs and chiropractors. *Methods*: This was an exploratory, qualitative study conducted with GPs and chiropractors in Newfoundland and Labrador. The interview guide was informed by the National Institutes of Health Behavior Change Consortium fidelity checklist, while data

analysis was guided by the Theoretical Domains Framework. Data were analysed deductively (coding participant quotes into one or more domains) and inductively (generating belief statements at each domain) before domains relevant to enhancing fidelity of provider training or intervention delivery were identified.

Results: Five GPs and five chiropractors working in both urban and rural settings participated in this study. Barriers and enablers to enhancing fidelity to provider training were related to seven TDF domains: [1] beliefs about capabilities, [2] optimism, [3] reinforcement, [4] memory, attention, and decision processes, [5] environmental context and resources, [6] emotion, and [7] behavioural regulation. Barriers and enablers to enhancing fidelity to intervention delivery were related to seven TDF domains: [1] beliefs about capabilities, [2] optimism, [3] goals, [4] memory, attention, and decision processes, [5] environmental context and resources, [6] social influences, and [7] behavioural regulation.

Conclusion: Time was perceived as the largest barrier to attending training, while incentives and flexibility in the training were perceived as enablers to attending training. Patient pressure, time, and established habits were perceived as the largest barriers to delivering the intervention as intended, although there were some conflicting beliefs related to time and patient pressure. Participants suggested enhancement strategies that might improve their ability to deliver the intervention as intended, including reminders and regular check-ins with researchers. Overall, most participants perceived the concept of intervention fidelity as important. These results may aid in the development of a more feasible and pragmatic intervention to reduce non-indicated imaging for GPs and chiropractors in Newfoundland and Labrador.

4.3 Introduction

Non-specific low back pain (LBP) is a common condition (121) defined as LBP where the pathoanatomical cause of pain cannot be determined (3, 4). Non-specific LBP likely develops from a complex interaction of biophysical, psychological, and social factors (2), and red flags indicative of specific spinal pathologies (e.g., fracture, infection, cancer), are typically not present in individuals who present with non-specific LBP in primary care (7). Clinical practice guidelines for the management of LBP (15) recommend against the use of routine diagnostic imaging in patients with non-specific LBP, and most only recommend imaging in the presence of red flags or if imaging would change a patient's treatment plan (15).

Despite relatively consistent guideline recommendations from around the world, the use of diagnostic imaging in primary care practices remains common (21, 22). Various interventions have been developed to improve the appropriate use of imaging for LBP, including education interventions for clinicians, audit and feedback, and clinical decision support tools (28, 29). However, the evidence of effectiveness for these interventions has been variable (28, 29). One reason for the variation in effectiveness across studies may be due to poor intervention fidelity, meaning that interventions may not have been delivered or implemented as intended (33, 34).

In health behaviour change research, intervention fidelity refers to "the methodological strategies used to monitor and enhance the reliability and validity of behavioural interventions" (45, 47). Knowledge of intervention fidelity can aid in the interpretation of the results of effectiveness trials (45). For example, if an intervention was found to be effective but implemented with low fidelity, the effectiveness results may have been due to unknown factors added to or omitted from the intervention. If an intervention was found to be ineffective and was also implemented with low fidelity, it would not be possible to determine if the intervention was actually ineffective, or if it was just not implemented as intended.

The National Institutes of Health Behavior Change Consortium (NIHBCC) developed a framework for intervention fidelity, which includes five areas of fidelity: study design, training, delivery, receipt, and enactment (45). Fidelity to study design refers to the study being able to adequately test the hypothesis in relation to an underlying theoretical framework. Fidelity to provider training refers to the training provided to the people who will be implementing an intervention. Fidelity to intervention delivery refers to the actual delivery of the intervention by providers as intended by the intervention developers. Fidelity to intervention receipt refers to the ability of participants to understand and perform the skills delivered during the intervention session. Fidelity to intervention enactment refers to the ability of participants to understand and perform the skills in real-life settings. The NIHBCC produced a validated checklist with strategies to enhance and/or assess intervention delivery within the five domains to accompany their intervention fidelity framework (35, 47).

Currently, little is known about intervention fidelity within studies of interventions aimed at reducing non-indicated imaging for LBP (28, 73). A multi-jurisdictional project aiming to test the effectiveness of a theory-informed intervention to reduce non-indicated imaging for LBP is being planned. The intervention will be adapted from a similar intervention developed using the Behaviour Change Wheel and the Theoretical Domains Framework (24). The intervention will consist of clinical education, a clinician-patient decision aid, and an educational booklet with reminders to indications for imaging and evidence-based, patient-specific management strategies. Exploring ways to enhance intervention fidelity in the early stages of intervention development can be a feedback mechanism to improve the main trial and can provide an opportunity to optimise the intervention and lead to a more accurate interpretation of the trial results (52, 53). Therefore, there is a need to find ways to enhance intervention fidelity during the design and development stage of this proposed intervention to reduce non-indicated imaging for LBP.

4.4 Objectives

This study had two objectives:

[1] To explore perceived barriers and enablers to enhancing *fidelity of training* of general practitioners (GPs) and chiropractors to deliver a proposed intervention aimed at reducing non-indicated imaging for LBP.

[2] To explore perceived barriers and enablers to enhancing *fidelity of delivery* of a proposed intervention aimed at reducing non-indicated imaging for LBP by GPs and chiropractors.

4.5 Methods

4.5.1 Design

We conducted an exploratory, qualitative interview study describing GPs' and chiropractors' perceived barriers and enablers to enhancing fidelity of training and delivery for a proposed intervention aimed at reducing non-indicated imaging for LBP. The perceived barriers and enablers were analysed using the TDF. This qualitative study was reported according to the COnsolidated criteria for Reporting Qualitative research (COREQ) checklist (Appendix 6). A protocol for this study was developed prior to the start of the study and submitted for publication (122).

4.5.2 Participant selection

Community-based GPs and chiropractors who held a license and were registered in the province of Newfoundland and Labrador (NL), Canada, were currently in practice (i.e., involved in direct patient care), and regularly managed patients with LBP were eligible for this study. Both GPs and chiropractors routinely manage patients with LBP and can order imaging, particularly radiographs, within the province.

Purposive snowball sampling was used to identify study participants. We chose this form of sampling to ensure a wide representation of participants from across NL. Participants were recruited through professional and research networks and associations across NL using email. At the end of each interview, participants were asked to identify an additional two people who may be interested in participating in the study. With all recruitment strategies, emphasis was placed on seeking GPs and chiropractors from both urban and rural regions of NL and on seeking participants who may have differing views or practice patterns to ensure a wide range of perspectives and to avoid premature saturation.

Our sample size was informed by the principles for deciding saturation in theory-based interviews proposed by Francis *et al*. (123). We conducted and analysed a minimum of 10 interviews to determine if we reached thematic saturation (i.e., the point where no new domains in the TDF were identified). A stopping criterion of three was used, meaning that if new domains were identified in the last three interviews, an additional three interviews would be conducted, up to a maximum of 20 interviews.

4.5.3 Interview procedures

Semi-structured interviews with open-ended questions were conducted by two members of the research team (DT and AP). One interviewer was a graduate student with limited experience in conducting interviews, and the other was a researcher trained in qualitative methods and interview techniques with over 15 years of experience. Both researchers have an interest in primary care and LBP research and one researcher (DT) is also a

practising chiropractor. Since participants were recruited through professional and research networks and associations that some of the research team members were members of, there was the possibility that some participants may have known the researchers prior to study commencement; however, participants only learned about the intentions and objectives of the interviews through the project information letter at the time of recruitment.

Interviews were conducted over a videoconferencing platform, Cisco Webex (Cisco Systems, Milpitas, United States). The following demographic questions were collected at the start of the interview: profession (GP or chiropractor); practice location (urban or rural); and number of years in practice. The primary investigator (DT) then provided a brief presentation on intervention fidelity (what it is and why it is important), the aims of the interview, and proposed strategies to enhancing fidelity to provider training and delivery for the proposed intervention. All interviews were audio-recorded and transcribed verbatim. No additional researchers or observers were present during the interviews and field notes were not taken.

4.5.4 Interview guide

The interview guide (Appendix 7) was adapted from a previous study which aimed to develop an intervention fidelity protocol for an intervention to promote self-management for people with chronic LBP or osteoarthritis (53). The questions in our interview guide were also guided by the fidelity to provider training and intervention delivery components

of a checklist of enhancement strategies developed by the NIHBCC (35). Participants were asked specifically about their thoughts on (including barriers and enablers) various strategies to enhance fidelity to provider training and intervention delivery for the proposed intervention. Content experts in qualitative research (HE), intervention fidelity (ET), and LBP were consulted to establish face validity of the interview guide. The interview guide was pilot tested with two participants and refined to include additional prompts.

4.5.5 Data analysis

Data analysis was guided by the Theoretical Domains Framework (TDF) (37), which contains 14 theoretical domains, covering 84 theoretical constructs (38). The TDF is a theoretical framework designed for the implementation of evidence-based practice (37) which has been used across health behaviour change research to identify influences (i.e., barriers and enablers) on the implementation of specific health behaviours (39). Data was analysed using a three-step process: [1] domain coding; [2] generating specific belief statements; and [3] identifying relevant domains (39).

Domain coding

The TDF was used as the coding framework to code and analyse the data. Prior to the start of coding, the primary investigator (DT) developed a codebook for each domain in the TDF (Appendix 8). The codebook was reviewed by another research team member experienced in coding interview data using the TDF (AMP). The codebook was also refined with the coding of additional interviews. Coding began after two interviews were

conducted. Interviews were coded using NVivo (V12, QSR International, Melbourne, Australia). Two coders (DT and RL) read the transcripts until they were familiar with the data prior to beginning coding. The reviewers independently coded participant responses into the relevant theoretical domain(s). The coders met for consensus after coding each interview and a third member of the research team (AP) was consulted if discrepancies persisted.

Generating specific belief statements

One coder (DT) generated statements representing the key message of each response (i.e., a specific belief). The list of specific beliefs was reviewed by another member of the research team (AP) for completeness and accuracy.

Identifying relevant domains

One coder (DT) identified the domains representing key barriers and enablers to enhancing fidelity to provider training or intervention delivery of the proposed intervention. The domains most likely representing perceived barriers and enablers were identified through considering the frequency of the belief statements, the presence of conflicting beliefs (i.e., participants reporting mixed views for a particular strategy to enhance fidelity to provider training or intervention delivery), and the perceived strength of the impact a belief may have on enhancing fidelity to provider training and intervention delivery (i.e., participants expressing beliefs they were particularly vocal about determined by length of participant quote or the use of emphatic or emotional speech) (39, 40). Using these criteria, the research team decided to take a more

conservative approach to considering domains as non-relevant. We determined that domains were non-relevant if no participant quotes were coded to that domain, or if only one participant expressed this belief and the perceived strength of this belief was low (identified by less text and if they did not demonstrate any emphatic or emotional speech). The relevant and non-relevant domains were checked by another member of the research team (AP).

4.5.6 Deviations from protocol

The current study explored the perceived barriers and enablers to enhancing fidelity to provider training and intervention delivery. The study did not explore perceived barriers and enablers to assessing fidelity to provider training and intervention delivery, as assessment strategies were beyond the scope of the current study's objectives. Therefore, responses to questions in the interview guide related to assessment strategies were not coded or reported for this study but will be analysed as part of a larger project on intervention fidelity. The protocol also described the use of the "other" domain to code participant quotes that did not reflect barriers or enablers related to enhancing fidelity to provider training and intervention delivery. Responses in this domain related to the participants' general perception of the intervention material or perceived acceptability of the intervention, which was beyond the scope of this current study. Therefore, responses coded in the "other" domain were not reported in the current study and will be analysed as part of a larger project on intervention fidelity. Lastly, Fleiss' kappa was not used

during coding. As described in the protocol, coders always coded to consensus and resolved any discrepancies through discussion.

4.5.7 Ethics

This study received ethics approval from the Newfoundland and Labrador Health Research Ethics Board (HREB #2020.299) (Appendix 9). Verbal consent was obtained and documented at the start of the interview. Completion of the interview implied that the participant consented to the entire interview and that consent was not withdrawn during this period.

4.6 Results

4.6.1 Participants

We conducted interviews with 10 participants (five GPs, five chiropractors), which was when data saturation was reached. Five participants practised in an urban setting (three GPs, two chiropractors), while five participants practised in a rural setting (two GPs, three chiropractors). The participants were in practice for an average of 13 years (range 1 – 32 years). No participants refused to participate or dropped out of the study. All interviews were conducted through videoconferencing with the participants either at home or in their clinics. Interviews took between 50 to 65 minutes. No repeat interviews were carried out and transcripts were not returned to participants for comments or correction. Participant checking was not performed.

4.6.2 Barriers and enablers to enhancing fidelity of provider training

The proposed intervention involves asking GPs and chiropractors to use an educational booklet with a clinician-patient decision aid, reminders of indications for imaging for non-specific LBP, and suggestions for providing evidence-based, patient-specific self-management strategies. To ensure the GPs and chiropractors understand the intervention and feel confident in delivering it as intended, a training session is proposed. The training session, which we were interested in getting feedback on, includes strategies to enhance learning, such as role play, using a participant training manual, and potential booster sessions. Specific to the domain of intervention fidelity related to provider training, we aimed to understand the barriers and enablers to the behaviour of attending the training session, followed by the behaviour of participating in the different training session strategies. As such, the barriers and enablers to both behaviours are described separately.

Relevant domains

Our analysis revealed various barriers and enablers to attending training related to the following domains: [1] beliefs about capabilities, [2] optimism, [3] reinforcement, [4] memory, attention, and decision processes, [5] environmental context and resources, [6] emotion, and [7] behavioural regulation. The specific beliefs with illustrative quotes for each of the relevant domains are presented in Table 4.1.

Fidelity to provider training: behaviour of attending training

Barriers: Five barriers related to attending training for this type of intervention were identified by participants. The strongest barrier was related to logistical issues preventing participants from attending the training sessions (*environmental context and resources*). For example, almost all participants believed that a lack of time, and a training session that was not flexible to their schedules, would be a challenge for them to attend. In-person training sessions were also thought to be a logistical challenge because they may be more difficult for clinicians working in rural areas of the province to attend if they were held in the capital city of the province. Some participants reported that they already felt confident in their ability to deliver this type of intervention, so they would not need to attend training (*beliefs about capabilities*), and one participant suggested that family physicians might take being asked to train for an intervention to reduce a commonly encountered issue like LBP as being critical of their existing skillset (*emotion*). Participants also felt that a barrier for attending training was clinician burnout, as they already had a lot of professional commitments and felt that attending training sessions would be daunting and overwhelming (*emotion*). Participants also suggested that they would not participate in training for this type of intervention if they did not see it benefitting their clinical practice (e.g., if the intervention did not help shorten their conversation with patients about why imaging for LBP is not indicated) (*memory, attention, and decision processes*).

Enablers: Three enablers related to attending training for this type of intervention were identified by participants. The strongest enabler was related to providing an incentive to attend training (*reinforcement*). Continuing education credits was the most popular type of incentive discussed; other suggestions for incentives included monetary compensation

for time away from work and offering catered events during the training sessions. Participants suggested some enablers that would help with overcoming logistical issues for training (*behavioural regulation*). Suggested enablers included having training sessions that were of a shorter duration and flexible session offerings that clinicians could choose from based on their schedules. Another suggested enabler was offering the training both synchronous and asynchronous, such as having a pre-recorded webinar or online course clinicians could complete on their own time followed by a live session with instructors to practise skills required to deliver the intervention. Participants generally felt optimistic about being trained in using this intervention, as they believed it to be a much-needed quality improvement initiative for their profession and were also excited to contribute to research (*optimism*).

Fidelity to provider training: participation in suggested training session strategies (e.g., role play, using a participant training manual, and potential booster sessions)

Barriers: No barriers related to participating in the suggested training session strategies were identified by participants.

Enablers: Three enablers related to participating in the suggested training session strategies were identified by participants. Participants were generally optimistic that the proposed training session strategies (e.g., role play, participant training manual, potential booster sessions) would help them to feel trained in using the intervention (*optimism*). Participants felt that having a manual they could review and refer back to on their own time would help them to train in using the intervention (*behavioural regulation*), and one

participant felt that in-person training sessions would be more beneficial to them because they felt burned out from virtual training (*behavioural regulation*).

Non-relevant domains

Our analysis revealed that barriers and enablers related to the domains of [1] knowledge, [2] skills, [3] social, professional role and identity, [4] beliefs about consequences, [5] intention, [6] goals, and [7] social influences were not relevant to enhancing fidelity to provider training of the proposed intervention. No data were coded at the domains of knowledge, skills, and intention. One participant felt that the training for this intervention could be a quality improvement initiative, which they considered an important part of their profession as a family physician (*social, professional role and identity*). One participant felt that virtual training would be challenging to participate and engage in (*beliefs about consequences*). One participant believed that an in-person training session was important to ensure that clinicians were invested in the intervention (*goals*) and that they would benefit from participating in group training sessions with other colleagues (*social influences*). The specific beliefs with illustrative quotes for each of the non-relevant domains are presented in Table 4.2.

Table 4.1 Barriers and enablers (including belief statements and sample quotes) of fidelity to the proposed provider training for relevant domains

Domain	Belief statement (Enabler/Barrier)	Sample quotes	Frequency (out of 10)
Beliefs about capabilities	I am confident in my ability to use an algorithm and/or provide a resource to patients without training. (*Barrier*)	"What you're proposing doesn't really sound like it needs much training. Like I think a lot of physicians hopefully already know this and if they're given an algorithm to follow, it sounds like it should be pretty straightforward." GP004	2
Optimism	I think the proposed training strategies (including role play, a training manual, and booster sessions) will help to ensure I feel trained in using the intervention as intended. (*Enabler*)	What do you think about some of these potential strategies for ensuring fidelity related to training? "I think they'll work." GP001 "I think they're awesome." DC005	6
		"I think they're all very reasonable…including the role play." GP002	
		"I think that [a training manual] would be helpful. Every bit of training is helpful. It's better that the practitioner has something to review and read before going into it blindly." DC002	
		"I think booster sessions would be really good." DC002	
	I think this intervention is great and would want to participate in training and delivering this intervention. (*Enabler*)	"And so I'm looking at this and I think this is phenomenal. Right? And you could follow and see what has changed in your practice and this is where I get all excited about QI because I think it's phenomenal." GP001	4
		"Having this conversation about research, I'm like excited – like 'Yes, I want to do this, that would be awesome'." DC004	
Reinforcement	Incentives (e.g., continuing education credits, monetary compensation) would help me to attend training as intended. (*Enabler*).	"It has to be CME (continuing medical education) accredited. Absolutely. You might get a few people doing it if it's not, but it's gotta be CME accredited." GP001	9
		"Well people love CE (continuing education) hours. If there's any way to get a simple set up for CE to it, that's always an incentive for people." DC003	
		"Honestly, being compensated for time. Because if physicians have to take time away from their practice to do this, you know,	

		you get paid to do work. So being compensated per hour that you spend in [training] would probably increase participation." GP002	
Memory, attention, and decision processes	I will not participate in this training if I do not see the benefit to my clinical practice. (*Barrier*)	"At the end of the day, there has to be a direct benefit to us as family physicians as to do we…like we all want to provide good care. But either this helps me cut the conversation shorter or helps me get the patient on my side quicker, right? So something has to help me be better than what I'm currently doing." GP003	2
		"I mean my gut is I don't think I would personally sign up for any kind of training session because I already engage [in other continuing education]. I just don't have enough time in my schedule to do that, especially where it's so specific to one type of intervention…just considering the grand scope of what we see in a day." GP005	
Environmental context and resources	Logistical issues (e.g., time, scheduling, location of training and associated expenses) would prevent me from attending training sessions. (*Barrier*)	[On challenges to attending training sessions] "It's just finding time in your private practice. That's it. Just time management." DC002	9
		"I just don't have enough time in my schedule to do that [training], especially where it's like so specific to one type of intervention." GP005	
		""It's difficult to come in and do these sessions. It's an expense. For me to go back and forth to the capital city, just in gas, if somebody had to stay in a hotel… So the challenge would be to get the rural people into the urban centre where you're most likely to have these in-person sessions." DC005	
Emotion	Provider burnout is a barrier to attending training for this intervention. (*Barrier*)	[On challenges to attending training sessions] "I think it's provider burnout." GP004	3
		[On attending training sessions] "It would be very daunting. I would feel overwhelmed by having to commit to extra training in order to use an intervention that's	

		supposed to either reduce time in my practice or make my quality of care better or improve the outcomes for my patients." GP005	
	Family physicians may be offended by being asked to participate in training for an intervention to reduce LBP imaging. (*Barrier*)	"And I think community physicians then get a bit jaded and they kind of get their backs up like "what do you mean, I don't know enough about LBP?!". You know what I mean? It just becomes kind of one more thing that we're being told that we're not very good at and we need to get better, which is true – we're not very good at this. I will be the first to admit it. But in a system that doesn't support our community family physicians very well, it can come across as being critical and can be taken incorrectly by those physicians I think." GP001	1
Behavioural regulation	The logistics of training (e.g., length of sessions, flexibility in scheduling, synchronous and asynchronous options) will help clinicians to complete the intervention training. (*Enabler*)	[On ways to overcome time or scheduling challenges] "Options. Being able to give a couple different options for people as to when they can attend. So they look at their calendar, these 3 options are out for me but I can make this one. Rather than it's happening this day at this time. I think being able to give people a little bit of leeway to figure out what time works best." DC003	8
		"You're going to have to make it very efficient…and I think a little bit of an a la carte, where I can do what I feel like I need to do. … I think you just need a tailored…or maybe multiple sessions so like I can attend the training session, but not attend the role playing session because I feel like I don't need that one in particular, right?" GP003	
		[On the ideal training time of a training session] "I would say no more than 2 hours. All together, in one sitting. Any more than that, it's kind of hard to get people to commit to. So I would say no more than 2 hours. You can do it split up, like you could do two 2-hour sessions if you felt like that much training was needed, but no more than 2 hours at a time." GP001	
		"I've seen the transportation from face to face to online/web courses. Anything people can do at say 9pm when they're home	

		from work, online. I'm looking for convenience. If I can do it online, that's perfect. This face-to-face stuff and traveling is done. A module, you review it and click – completed, completed, completed. And you can't finish that section until you've read it and check down 'yes I've done it'." DC002	
	A training manual (e.g., with charts and visuals, digital version) to review and refer back to on my own time would help me to train for using this intervention. (*Enabler*)	"But I do like the possibility of having something like a manual that if it's 8 o'clock on Monday night and I'm just sitting doing work, can I pull that up and just refresh that way? So having a manual but then also sitting in with everybody." DC003	5
		"PDF. I'll lose the paper. I never have the paper. I basically have, on my desktop computer, a folder for almost everything. Like I said, the moment it becomes not up to date then people will stop using it. So even if it's a webpage that I could just link to and it allows people to keep it up to date. Because if it's not up to date, people will just stop using it. A PDF is harder for you to keep distributing, while the web you can just update it." GP003	
	The opportunity to meet in-person in a group setting would help me to train for this intervention. (*Enabler*)	"Well I'm Zoom'ed out. … So the reality is that if and when we can get together more, I think that a group setting in a real, in-person group setting, in a room, I think would be way more beneficial." DC005	1
The relevance of a domain was determined through the consideration of the frequency of the belief statements, the presence of conflicting beliefs, and the perceived strength of the impact a belief may have on enhancing fidelity to provider training.			

Table 4.2 Barriers and enablers (including belief statements and sample quotes) of fidelity to the proposed provider training for non-relevant domains

Domain	Belief statement (Enabler/Barrier)	Sample quotes	Frequency (out of 10)
Knowledge	No relevant quotes coded to this domain		
Skills	No relevant quotes coded to this domain		
Social, professional role and identity	Quality improvement is an important part of my profession, as a family physician. (*Enabler*)	"This [training] is exactly what we want to be doing and this is quality improvement." GP001	1
Beliefs about consequences	I think virtual training would be challenging to participate in and really engage in. (*Barrier*)	"I think the challenge is right now, certainly, with Zoom. I think the challenge is that people are Zoom'ed out, just like me. They just don't want to be at it anymore. And I think that's going to be a huge challenge if you choose to do it like that. Because half of communication is body language, nuances, facial features, you know. Communication on Zoom is very difficult and you lose a big chunk of it. And if you're doing a group session, you're reading body language, you're reading little nuances in the way they look or giggle or whatever. And that's feedback – you know, positive or negative, it's still feedback. So that challenge I think is going to be there with Zoom." DC005	1
Intention	No relevant quotes coded to this domain		
Goals	An in-person training session is important to ensure clinicians are invested in the intervention. (*Enabler*)	"But I'm a sucker for having everybody on the same page, so to have a session and know that everybody's there and everybody's kind of paying attention and really invested in it. I always like that a little bit more." DC003	1
Social influences	It would benefit me to participate in group training sessions with other colleagues. (*Enabler*)	"It is actually nice to be able to sit down with your colleagues and go over this kind of stuff and hear different situations that other people have been in, similar to what you are." DC003	1
The relevance of a domain was determined through the consideration of the frequency of the belief statements, the presence of conflicting beliefs, and the perceived strength of the impact a belief may have on enhancing fidelity to provider training.			

4.6.3 Barriers and enablers to enhancing fidelity of delivery

As previously described, the proposed intervention involves asking GPs and chiropractors to use a clinical resource consisting of an educational booklet with a clinician-patient decision aid/algorithm, reminders to indications for imaging for non-specific LBP, and suggestions on providing evidence-based, patient-specific self-management strategies. Specific to the domain of intervention fidelity related to intervention delivery, we aimed to understand the barriers and enablers to the behaviour of actually delivering the intervention by GPs and chiropractors to their patients.

Relevant domains

Our analysis revealed various barriers and enablers related to the following domains: [1] beliefs about capabilities, [2] optimism, [3] goals, [4] memory, attention, and decision processes, [5] environmental context and resources, [6] social influences, and [7] behavioural regulation. The specific beliefs with illustrative quotes for each of the relevant domains are presented in Table 4.3.

Barriers: Some participants reported that they would not be confident in delivering the intervention as planned in certain situations (e.g., if they were short on time, received pushback from patients, if they had to educate on self-management strategies) (*beliefs about capabilities*). Some participants believed that since they already had their own ways (or would develop their own ways of explaining why imaging is not indicated to patients), they may not stick to a particular script and thus may not deliver the

intervention as intended (*memory, attention, and decision processes*). Some of the GPs in our sample also reported that delivering the intervention as intended was only important if they believed non-indicated imaging was an important issue and if they thought the intervention aligned with the appropriate standard of care they already provided for patients with LBP (*goals*). Most participants believed a lack of time would be a barrier for delivering the intervention as planned (*environmental context and resources*), with some participants reporting that they would not deliver the intervention as intended if it took too much time (*memory, attention, and decision processes*); however, one participant did not feel that time would be a barrier to delivering the intervention in their practice (*environmental context and resources*) and another participant felt confident in being able to deliver the intervention as planned, without being worried about time (*beliefs about capabilities*). Lastly, some participants identified that patient pressure/demands for imaging would influence their ability to deliver the intervention as intended (*social influences*), although other participants did not believe that patient pressure would influence their ability to deliver the intervention as intended (*social influences*).

Enablers: Overall, participants felt the proposed intervention delivery enhancement strategies (e.g., clinical algorithm, script) were great ideas and would help them to deliver the intervention (*optimism*). They were also confident they could deliver the proposed components as planned (*beliefs about capabilities*). Participants reported that delivering the intervention as planned was important to them, with many understanding that doing otherwise compromises the study and any value that can be gained from implementing the intervention (*goals*).

Many participants felt that features of the training for this intervention (e.g., having a training session, using role play, having a participant training manual, having booster sessions) would help them to remember how to deliver the intervention as intended (*memory, attention, and decision processes*). For example, having a participant training manual that they could refer back to would allow them to quickly review the content before they needed to deliver the intervention. Additionally, all participants suggested that having regular check-in times would help them to deliver the intervention as intended. However, the mode of check-in varied from group-based booster sessions to progress emails from the research team to having the ability to reach out to the research team via a clinical coach or champion when needed (*behavioural regulation*). Participants also felt that the proposed features of the intervention itself (e.g., algorithm, script for patient discussions, session checklist) and reminders of the intervention components potentially built into the electronic medical record would help them to remember how to deliver the intervention (*memory, attention, and decision processes*). All participants suggested that having a script with key talking points (instead of a word-for-word script) that would allow for flexibility in how they discuss with their patients would help them to deliver the intervention as intended (*behavioural regulation*). Some participants also suggested that having some flexibility in the intervention material formats would help them to actually use the intervention material as intended, with some preferring digital copies, others preferring paper copies, and others preferring digital copies built into the electronic medical record (*behavioural regulation*). Participants in our study also suggested that tailoring the intervention to fit within a regular appointment

time (e.g., 5-10 minutes for GPs and 15-20 minutes for chiropractors) would enable them to deliver the intervention as intended (*behavioural regulation*).

Non-relevant domains

Our analysis revealed that barriers and enablers related to the domains of [1] knowledge, [2] skills, [3] social, professional role and identity, [4] beliefs about consequences, [5] reinforcement, [6] intention, and [7] emotion were not relevant to enhancing fidelity to provider training and delivery of the proposed intervention. No data were coded at the domains of knowledge, skills, social, professional role and identity, beliefs about consequences, and intention. One participant believed that the established clinical routines of clinicians may make delivering the intervention as intended more difficult, explaining that breaking those clinical habits in order to implement new changes would be a difficult process (*reinforcement*). One participant felt they would feel comforted by having a training manual they could refer to in order to deliver the intervention as intended (*emotion*). The specific beliefs with illustrative quotes for each of the non-relevant domains are presented in Table 4.4.

Table 4.3 Barriers and enablers (including belief statements and sample quotes) of fidelity to the proposed intervention delivery for relevant domains

Domain	Belief statement (Enabler/Barrier)	Sample quote	Frequency (out of 10)
Beliefs about capabilities	I am confident I can deliver this intervention as planned. (*Enabler*)	How easy or difficult do you think it would be to adhere to delivering say 80% of the intervention components? "I think it would be pretty easy to do that, yeah." DC004	6
		"I don't think 80% is too hard." GP003	
	I would not be confident in delivering this intervention as planned in certain situations (e.g., pushback from patients, if I had to educate on self-management strategies, if I was limited on time, if patient had other reasons for presenting for care). (*Barrier*)	"As I had alluded to earlier, my patients rarely ever book an appointment just to talk about their back pain. And so what inevitably would happen, even if we did just book an appointment for their back pain, is that we would get partway through this, and it would make them think about…something else…and then we would end up totally off topic. And so it can be difficult in going through an intervention like this to try to keep it contained, because it's difficult to keep anything contained, and so that can be tricky." GP001	5
		"I mean…self-management strategies are always a difficult conversation…difficult to deliver to a patient. And reassurance and education. I mean, they're so important but they are the things that take the longest I find in practice. And often times, patients aren't always willing to do the self-management techniques at home" DC004	
	I am confident I can deliver this intervention during my clinic encounter, without being worried about time. (*Enabler*)	"I can manage to get a lot of the information out in a reasonable amount of time." GP002	1
Optimism	I believe the proposed intervention delivery enhancement strategies (e.g., algorithm, use of a script)	[On the strategies for enhancing fidelity to intervention delivery] "I like all of them." DC003	4
		"I think it's great. I love algorithms." GP004	

	would help me to deliver the intervention. (*Enabler*)	"I like the script idea." DC003	
		"[Self-management strategies] is the part I look most forward to. That's the part I want the most out of. Because like I said, patients don't get an x-ray but then they leave with some really good information of things that they can do to help with their cause. So that's the thing that would get you the buy in for the whole program." GP003	
Goals	It is important for me to deliver the intervention as planned. (*Enabler*)	[On the importance of delivering the intervention as planned] "It's very important. I think it's very necessary." DC002	7
	Delivering this intervention as intended is only important to me if I believe non-indicated imaging is an important issue and if the intervention aligns with the appropriate standard of care I provide. (*Barrier*)	"How big of a problem a particular individual provider views imaging for lower back pain…how important they think it is to their practice is going to decide whether or not they use the tool or are committed to it." GP001	2
		"I think that my priority is always am I giving the standard of care that's appropriate to the clinical situation to my patient. So if this situation looked like it would be appropriate to fit the intervention, then I would use the intervention to the best that I could to meet the clinical scenario." GP005	
Memory, attention, and decision processes	Features of the training for this intervention (e.g., in-person training session, use of role play, training manual, booster sessions) would help me remember how to deliver the intervention as intended. (*Enabler*)	"But I'm a sucker for having everybody on the same page, so to have a session and know that everybody's there and everybody's kind of paying attention and really invested in it." DC003	6
		"I mean, there's no question role playing is very important. I mean, you could read something and it just quickly dissipates from your brain as time goes. And if you solidify that with a concrete learning example like role playing, I think it's essential." DC005	
		[On the importance of a training manual]	

		"Then if I do this once every 3 months or once every 9 months, I don't have to try to remember what I did at the last session, but I could quickly go in 2 minutes and review things myself, and then it's very fresh when I see the patient. So to me, for someone who's busy, that would be super super helpful." GP004	
		"But definitely, the regular booster sessions as well help if it's a study that's going over a long period of time. People sort of lose and forget what they're doing and sometimes just that meeting to make sure people are still on the right track is good." GP002	
	Proposed features of the intervention (e.g., algorithm, script for delivery or patient discussions, session checklist) and reminders of the intervention components built into the electronic medical record would help me remember how to deliver the intervention as intended. (*Enabler*)	"The clinical resource is a definite huge bonus. Anything you can reach to quickly give yourself a refresher or make sure you've checked all your bases is nice." DC003	4
		"Having a checklist as part of the resource, that these are your main talking points and I've got it printed out or pinned up in the office that if the conversation comes up, I can look it over" DC003	
		"But I think just having a little bit of detail on the EMR, it would probably make sure that people remember it [the components of the intervention]" GP004	
		"The script for delivery is actually not bad because after a time, it becomes part of your normal lingo, right? So you start off sort of mechanically, I guess, in a way. Sort of saying 'this is what we're doing blah blah blah'. It eventually becomes part of what your dialogue is." GP002	
	I may not deliver the intervention as intended because I already have or will develop my own way of explaining concepts around imaging and LBP. (*Barrier*)	"I think too, once I've implemented it, like for example, once I've used the tool, let's say we use the clinician decision tool. Once I've used it once or twice, I don't need to bring it up every time, because I've got it right? So like, the main part would be like, I guess…because it's very much dependent on the patient. So like there's some flexibility in how that program is also delivered. So like, did I use the decision making tool	3

		today? Well I didn't take out the decision making tool and look at it, but I did use it in my head." GP003	
		"I think similar to before, just having this become your autopilot vs. what I use right now when this conversation comes up. It's remembering to switch to this, which I guess in reality, is not too far different from what I already do, but for some people, maybe it would be a bit different." DC003	
	I may not deliver the intervention as intended if it takes too much of my time. (*Barrier*)	"But the moment it becomes cumbersome or takes more time, because time is ultimately the factor that not a lot of us have a lot of, and the moment that it becomes more time to do it, it will become less utilised properly." GP003	2
Environmental context and resources	Lack of time may be a barrier to delivering the intervention as planned. (*Barrier*)	"The biggest problem when it comes to clinical resources or decision tools or whatnot in family medicine is that we don't have any time." GP001	6
		"Time would definitely be a challenge. As a chiropractor, I know most only spend about 20 minutes with their patient and that's for a quick re-assessment, a conversation, and treatment." DC004	
	Time is not a barrier to delivering the intervention as planned. (*Enabler*)	"I'm not in fee-for-service anymore so I have the time to explain things well." GP004	1
Social influences	Patient pressure to order imaging will not prevent me from delivering this intervention. (*Enabler*)	[On patients being persistent on getting an x-ray] "There's some, but usually, when you talk about it, they come around to it." GP002	5
		"I think that would be something to contend with, but I don't think it would prevent me from [delivering the intervention]" DC001	

	Patient pressure for imaging may influence my ability to deliver this intervention as intended. (*Barrier*)	"Because ultimately, I find, it's not my clinical decision tools to know whether or not to do an x-ray that's the issue. My issue is the patient demanding to have an x-ray. That is ultimately what it brings it down to. … sometimes it's easier to not fight the fight and just say 'Here's your x-ray because you're not going to leave until you get one anyways'." GP003	3
		"But you'll always hit difficult people who want what they want regardless of whether it's going to be the most effective resource for them. So I think the biggest challenge you'll get is just personality or patient types." DC003	
Behavioural regulation	An intervention script with key talking points (that isn't too prescriptive) would help me to deliver the intervention as intended. (*Enabler*)	"Every practitioner has their own style of delivery. Just key points that have to be delivered. I think that would be the best way to do it." DC002	10
		"Every person is their own illness experience. Not everybody experiences low back pain the same way. … And I agree there's some people who would find that this is difficult to understand, so that may make it a bit of a challenge to delivering this – patients themselves. So you need to have a little bit of flexibility in the script and how you're delivering it." GP002	
		"I think speaking points because you would make your own way in how to do it. But you want to be able to touch on all the main things that you want to get into the session." GP003	
	I think having regular check-in times (e.g., booster sessions, progress check-in emails) and/or the ability to reach out to the research team (e.g., clinical coach or project champion) when needed would help me to deliver this intervention as intended. (*Enabler*).	"I really like the idea of a booster session. It makes a lot of sense. There are so many CME events that I go to and then I get all excited and I take it away and then I go to implement it into my practice and then it kind of falls apart… And a booster session that includes a component of bringing back difficult encounters or you know… 'I tried to use this tool on this patient and here's what happened. How could I approach that better next time or what did I do wrong?'. I think that would be very useful. … I think you have 1 booster session maybe 6-8 weeks out and that would be the best that we would be able to	10

		hope for when it comes to buy in and engaging people right now." GP001	
		"I think having a champion is a really good idea … if you had somebody that basically said 'I'm trained up on this. I'm happy and interested in helping'." GP001	
		"Having that touch base call every 4-6 weeks sometimes does get people get back on track and make them think about what the purpose of this is and the flow and answer any questions that they may have." GP002	
		"I don't know if I would spend time putting on a booster session. I would more say, 'This is our contact information. If you have an issue, then reach out to us.'." GP003	
		[On receiving support from the research team] "Regular emails, just reaching out to see if they need any assistance, see how their progression is." DC002	
	Tailoring the intervention to fit within a regular appointment time (5-10 minutes for GPs; 15-20 minutes for DCs) will help me to deliver the intervention as intended. (*Enabler*)	"If [LBP] were the only thing in the appointment, it would be ideal. Because in that case, then you could go through the whole thing about the indications and the education and the thing goes along with it, and then running through some of the interventions that they can do themselves to get started." GP002	5
		"I think if the script could be honed enough that it could be all done in 15-20 minutes for us anyways. It would be about fitting it into an appointment time." DC001	
	Flexibility in intervention material formats (e.g., access to both digital and paper copies	"What I'm picturing is in the EMR or on a website, you can just bring up the tool and print it right from the computer. That way if you're moving around multiple clinic rooms and things,	3

	with the possibility of having digital copies built into the electronic medical record) would help me to use the materials as intended. (*Enabler*)	you don't have to have multiple booklets and they get lost and stuff like that." GP001	
		"I'd say most people are pretty tech savvy at this point. So I've had good success with links and stuff, or just recommending go on YouTube and search this. Just the ease of being able to send that off. But a hard copy is…it's easy to give out and there's no barrier at that point. For anybody who doesn't have access to Internet or just doesn't go on as much to it. It eliminates all barriers." DC003	
The relevance of a domain was determined through the consideration of the frequency of the belief statements, the presence of conflicting beliefs, and the perceived strength of the impact a belief may have on enhancing fidelity to provider training.			

Table 4.4 Barriers and enablers (including belief statements and sample quotes) of fidelity to the proposed intervention delivery for non-relevant domains

Domain	Belief statement (Enabler/Barrier)	Sample quote	Frequency (out of 10)
Knowledge	No relevant quotes coded to this domain		
Skills	No relevant quotes coded to this domain		
Social, professional role and identity	No relevant quotes coded to this domain		
Beliefs about consequences	No relevant quotes coded to this domain		
Reinforcement	Clinicians' established practice routines may make delivering the intervention as intended challenging. (*Barrier*)	"I think similar to before, just having this become your autopilot vs. what I use right now when this conversation comes up. It's remembering to switch to this, which I guess in reality, is not too far different from what I already do, but for some people, maybe it would be a bit different." DC003	1
Intention	No relevant quotes coded to this domain		
Emotion	I would feel comforted by having a training manual to refer back to in order to know that I am delivering the intervention as intended. (*Enabler*)	[On the importance of a training manual] "For me, I think it would provide more comfort. I think instead of being something seen as a time consumer, I think I'd feel that as least I was being thorough and that I wasn't missing anything." DC001	1
The relevance of a domain was determined through the consideration of the frequency of the belief statements, the presence of conflicting beliefs, and the perceived strength of the impact a belief may have on enhancing fidelity to provider training.			

4.7 Discussion

We conducted a qualitative study which interviewed 10 GPs and chiropractors on their perceived barriers and enablers to enhancing fidelity of training and fidelity of delivery for an intervention aimed at reducing non-indicated imaging for LBP. Barriers and enablers to enhancing fidelity to provider training were related to seven domains in the TDF, with a variety of barriers and enablers described by participants. The main barriers for attending training centred around a lack of time to attend and some participants feeling they did not need to attend either because they already felt confident in managing patients with LBP without imaging or because they did not see the benefit to using this type of intervention in their clinical practice. The main enablers for attending training were having incentives to attend and having flexibility in the training scheduling and format. Barriers and enablers to enhancing fidelity to delivery related to seven domains in the TDF, again, with a variety of barriers and enablers described by participants. A barrier was that participants may not deliver the intervention as intended because they had established habits on how to discuss why imaging for LBP was not indicated; however, some enablers suggested by participants included having a flexible script with key talking points and regular check-ins with the research team to ensure they were delivering the intervention as intended. Time and patient pressure were believed by most to be barriers to delivering the intervention as intended, and participants suggested that ensuring the intervention fit within the timeframe of their regular clinic appointment would help enable them to deliver the intervention as intended. Lastly, a strong enabler was that most

participants recognised the importance of intervention fidelity and delivering the intervention as planned.

4.7.1 Findings in context with existing literature

Few studies have explored the perceived barriers and enablers to enhancing provider training and intervention delivery for interventions aimed at reducing non-indicated imaging for LBP. The proposed intervention described in our current study is based on the intervention developed by Jenkins *et al.* (24, 124), which involves GPs delivering a LBP management booklet to patients to reduce non-indicated imaging for LBP. For that intervention, two studies exploring barriers and facilitators to implementation of the intervention were conducted, once during the intervention development process (24) and once during a feasibility study after GPs used the intervention with their patients (124). A barrier identified in both studies was that delivering the intervention was time-consuming (24, 124), which was also identified as a perceived barrier for intervention delivery by most participants in our study. An enabler identified by both studies by Jenkins *et al*. was that GPs preferred both digital and paper formats for the intervention materials, as they believed digital formats were easier to store, could be kept up to date, and would serve as a reminder for them to use the intervention (24, 124), which were also perceived enablers in our study. While Jenkins *et al*. (124) did not explore barriers and enablers to attending training for the intervention, all GPs attended a training session, which was a 20-minute individualised face-to-face session with a member of the research team. During the training session, GPs were provided with education on the appropriate use of imaging for

LBP, an introduction to the LBP management booklet, and received a demonstration on how to use the booklet (124).

The perceived enablers for attending training that we identified in our study are similar to those identified in other studies on complex behaviour change interventions. Incentives are commonly used as an implementation strategy to improve practice behaviours of physicians (125), as well as within clinical trials to improve recruitment and retention of health professionals (126); however, incentives may take a variety of formats, including continuing education, financial, or co-authorship. Additionally, in a study which used online training to train physical therapists in delivering an online, group-based program to patients with LBP, participants felt that virtual training sessions allowed for greater flexibility in scheduling (127). However, they also felt that peer support and practice-based learning activities from face-to-face interactions were lacking (127). These beliefs were also held by participants in our study, who believed there would be value in having both virtual and in-person training sessions as options.

All participants in our study believed that some form of check-in with the research team would be important throughout the period they were delivering the intervention (e.g., during a trial), although the methods they suggested for regular check-ins varied. Similarly, in the development of a fidelity protocol for a complex self-management intervention delivered by physical therapists, Toomey *et al.* found that participants reported regular contact with the research team to prevent skill drift was acceptable (53).

This resulted in including regular communication methods between the research team and physical therapists when fidelity protocol was developed (53).

4.7.2 Strengths

This was the first study to use the TDF to explore perceived barriers and enablers to provider training and intervention delivery for an intervention aimed at reducing non-indicated imaging for LBP. Our sample included GPs and chiropractors from across the province of NL and found similar barriers and enablers. This might suggest that an intervention developed to reduce non-indicated imaging for LBP may be used by health professionals. We used the TDF as our coding framework, which may allow for a theoretical explanation for the participants' behaviours related to fidelity to provider training and intervention delivery.

4.7.3 Limitations

Since participants volunteered for the study, they may have been more likely to feel that non-indicated imaging was an important issue, potentially resulting in premature saturation. To avoid this, we specifically tried to target participants in different geographical regions of NL and when using snowball sampling, we specifically asked for additional participants with differing views. The interview guide was developed based on the NIHBCC fidelity framework, as we wanted to prioritise capturing key concepts related to intervention fidelity. However, the TDF was used as the coding framework for analysis, which may have resulted in less questions and responses directed at specific domains in the TDF. This may be a reason why some domains had no relevant participant

quotes; future studies using the TDF for the primary analysis may consider using a TDF-based interview guide. The primary interviewer was not as experienced with conducting interviews and may not have asked enough probing questions, which may also have resulted in fewer relevant participant quotes at some domains. Additional pilot testing of the interview guide may have been needed to determine if more probing questions were needed.

4.7.4 Implications for research

Our findings can contribute to the development of an intervention aimed at reducing non-indicated imaging for LBP by providing suggestions on how to enhance fidelity to provider training and intervention delivery. The strongest barriers related to attending training and delivering the intervention should be addressed. The training for this intervention should be flexible in its format and scheduling to accommodate for participants' varied schedules, previous education and experience, and learning styles. An incentive would also need to be provided for participants to attend training. The delivery of the intervention should fit within a regular clinical appointment time (i.e., less than 15 minutes) and a variety of formats for delivery could be considered, including both paper and digital versions of the intervention. Various forms of reminders (e.g., reference to a participant training manual and flexible intervention script) should also be provided to participants delivering the intervention so they can more easily remember how to deliver the intervention and remember what the components of the intervention are. Participants would also likely benefit from follow up from the research team during the intervention delivery period in the form of contacting the research team on an as-needed basis. Our

study revealed conflicting beliefs on patient pressure as a barrier to delivering the intervention as intended, which could be further explored in future research.

4.8 Conclusion

Exploring factors affecting intervention fidelity and ways to enhance intervention fidelity during the early stages of intervention development can help improve the results and interpretation of the main effectiveness trial for the intervention. We conducted a qualitative interview study to explore perceived barriers and enablers to enhancing fidelity to provider training and intervention delivery for a proposed intervention to reduce non-indicated imaging for LBP. Barriers and enablers to fidelity of provider training were related to seven TDF domains, with time as largest barrier related to attending training and incentives and flexibility in the required training as the largest enablers. Barriers and enablers to fidelity of intervention delivery were related to seven TDF domains, with patient pressure, time, and existing habits as the main barriers related to being able to deliver the intervention as intended. Participants suggested various enhancement strategies that would improve their ability to deliver the intervention as intended, including having reminders on how to use the intervention and regular check-ins with the researchers. These results may aid in the development of a more feasible and pragmatic intervention to reduce non-indicated imaging for GPs and chiropractors in NL.

Chapter 5: Discussion

5.1 Summary of findings

The overall objective of this thesis was to examine strategies that have been used to enhance and assess intervention fidelity for interventions targeting GP behaviour to reduce non-indicated imaging for LBP, and to explore perceived barriers and enablers to enhancing fidelity of training and fidelity of delivery to a proposed intervention for reducing non-indicated imaging for LBP. Two studies were conducted within this thesis: a systematic review on the reporting of strategies used to enhance and/or assess fidelity for interventions to reduce non-indicated imaging for LBP, and a qualitative interview study exploring perceived barriers and enablers to enhancing fidelity of training and delivery for a proposed intervention to reduce non-indicated imaging for LBP in Newfoundland and Labrador, Canada.

5.1.1 Summary of systematic review on the reporting of intervention fidelity

A systematic review was conducted to search the literature on the reporting of intervention fidelity within studies of interventions aimed at reducing non-indicated imaging for LBP. Twenty-seven articles, with a total of 50 intervention components used, were included in the review. There was limited reporting of strategies used to enhance or

assess intervention fidelity within this context. The strategies reported most often were those to enhance fidelity of study design or intervention delivery. The use of strategies to assess fidelity was infrequently reported. Only four studies, with a total of four intervention components, explicitly measured intervention fidelity. Three provided outcomes on intervention fidelity, and one partially reported on the psychometric properties of tools used to measure intervention fidelity.

5.1.2 Summary of qualitative study on perceived barriers and enablers to enhancing fidelity of provider training and intervention delivery

A qualitative interview study with a sample of GPs and chiropractors in the province of NL was used to identify perceived barriers and enablers to ensuring fidelity of provider training and intervention delivery for a proposed intervention to reduce non-indicated imaging for LBP. Time was perceived as the largest barrier to attending training, while incentives and flexible training were perceived as enablers. Patient pressure, time, and established habits were perceived as barriers to delivering the intervention as intended. Suggested enhancement strategies, such as reminders and regular check-ins, were perceived as enablers. Overall, most participants perceived the concept of intervention fidelity as important.

5.1.3 Overall thesis summary

Overall, strategies to enhance and assess fidelity to interventions aimed at reducing non-indicated imaging for LBP appear to have been unused, or not reported to be used, in the published literature. Specifically for interventions which involved training or education of GPs, the literature indicated that incentives (e.g., continuing education credits) (99, 107, 108), group in-person training (87, 88, 90, 102, 107, 108), and recorded sessions for those who could not attend (99, 107) were used as strategies to enhance attendance at training sessions. Data from the interviews conducted as part of this thesis align with these findings, as participants also believed that incentives such as continuing education credits would be an enabler to attending training, and they stressed the importance of having flexible training, including options such as group training or recorded (i.e., asynchronous) sessions. Recorded training sessions may also serve as a reminder on how to use the intervention, which aligns with interview participants' belief that a training manual would serve as a reminder on how to deliver the intervention. Only one intervention identified in the systematic review asked GPs to explain why imaging is not necessary to their patients (88). In this study, standardised patients made unannounced visits at the clinic where those encounters were assessed to determine if GPs were delivering the intervention as intended. The use of standardised patients was not a strategy discussed during participant interviews and may also not be feasible for the proposed intervention, as it would be costly and difficult to conduct when the study involves participants from across the province.

5.2 Contribution to the literature

This thesis highlights that currently, little is known about intervention fidelity within interventions aimed at reducing non-indicated imaging for LBP. This demonstrates there is a need to better use and subsequently report strategies to enhance and assess intervention fidelity when future interventions aimed at reducing non-indicated imaging for LBP are developed. This aligns with the Template for Intervention Description and Replication (TIDieR) checklist and guide, which aims to improve the reporting of interventions (120). All five domains of intervention fidelity should be considered when developing and describing an intervention: the intervention should be described completely and based on a theoretical framework (domain: study design); details of how the providers will be trained should be described, including any tools used to enhance providers' understanding of their training or methods used to assess providers' understanding of their training (domain: training); details of how delivery of the intervention will be enhanced and assessed should be described, including how the researchers will ensure the content and dose of the intervention will be delivered (domain: intervention delivery); intervention recipients' understanding of the intervention should be described (domain: intervention receipt); and how recipients of the intervention are using the intervention in real-life settings should be described (domain: intervention enactment). The interview study in this thesis also highlights that it is feasible to conduct interviews with participants in the intervention planning phase to determine how intervention fidelity can be enhanced in the main trial.

5.3 Future research

More work needs to be conducted on the psychometric properties of the measurement methods used to assess intervention fidelity. The psychometric properties of methods used to actually measure intervention fidelity have previously been synthesised for complex, face-to-face health behaviour change interventions (118). While the majority of studies did not report whether the measure used was developed on their own or previously developed, most studies reported at least one psychometric property (i.e., related to validity or reliability). This finding contrasts with the findings of our review, which reported few studies actually measured intervention fidelity and only one study partially reported on the psychometric properties of the measurement tools used. This information will be helpful for intervention developers aiming to develop an intervention fidelity protocol to improve the overall interpretation of the results of their studies. Such information will also be helpful for stakeholders involved in policy, funding, and health services research, as they can have a better understanding of whether intervention fidelity was adequately reported and/or assessed to determine if intervention fidelity may have impacted the results of the study and if the intervention should be implemented or not.

Only GPs and chiropractors were interviewed in the qualitative study. In order to develop a comprehensive intervention fidelity protocol, the perceptions of the intervention developers and patients with LBP (who will be the recipients of the intervention) also need to be considered. By taking those perspectives into consideration, further strategies

to enhance and assess intervention fidelity to the domains of study design, intervention receipt, and intervention enactment can be developed and included in the intervention fidelity protocol.

Chapter 6: Conclusion

Non-indicated imaging for LBP is an issue that needs to be addressed, as diagnostic imaging continues to be inappropriately used in primary care practices. When designing an intervention to be tested in a trial, intervention fidelity (i.e., the degree to which an intervention is implemented as intended) is an important consideration, as it has implications for both the internal and external validity of the trial results. While many interventions have been developed to target non-indicated imaging for LBP, it is unknown whether intervention fidelity was adequately studied within these interventions. With the plan for the development of a new intervention to target non-indicated imaging for LBP in NL, Canada, it is important to identify factors which may impact intervention fidelity for this intervention. To address these gaps in the literature, the overall objective for this thesis was to examine strategies that have been used to enhance and assess intervention fidelity for interventions targeting GP behaviour to reduce non-indicated imaging for LBP, as well as to explore perceived barriers and enablers to enhancing fidelity of training and fidelity of delivery to a proposed intervention for reducing non-indicated imaging for LBP.

The systematic review in this thesis demonstrated that strategies to enhance and/or assess intervention fidelity for interventions targeting GP behaviours related to non-indicated imaging for LBP have been poorly reported. When reported, mostly enhancement

strategies (and not assessment strategies) were reported in the studies. The most commonly reported enhancement strategies were for enhancing fidelity to study design and intervention delivery, with little emphasis placed on enhancing fidelity to provider training, intervention receipt, and intervention enactment. The qualitative interview study in this thesis identified that perceived barriers to attending training sessions included logistical issues (e.g., time and scheduling) and clinicians not wanting to attend training sessions, while enablers included incentives and increased flexibility in training (e.g., shorter duration, multiple sessions, asynchronous and synchronous options). Specifically, perceived barriers to delivering the intervention as intended included time, patient pressure, and established habits, while enablers included various enhancement strategies such as regular check-ins with the research team, a flexible script, a participant training manual, and an intervention that fit within a regular clinic appointment time. Overall, participants were optimistic about the intervention in reducing non-indicated imaging for LBP and they recognised the importance of intervention fidelity.

The studies from this thesis are important for informing the development of an intervention to reduce non-indicated imaging for LBP for GPs and chiropractors in NL, Canada. Specifically, information from these studies can aid in the development of an intervention fidelity protocol in order to appropriately enhance and assess intervention fidelity within the main trial for this intervention.

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Appendices

Appendix 1 PRISMA checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	26
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	27-28
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	28-31
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	31
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	32-34
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	32
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Appendix 3
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	34
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	34-38

Section and Topic	Item #	Checklist item	Location where item is reported
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	34-38
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	34-38
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	N/A
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	N/A
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	38-39
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	38-39
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	38-39
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	38-39
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	N/A
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	N/A
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	N/A
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	N/A
RESULTS			

Section and Topic	Item #	Checklist item	Location where item is reported
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	40-41
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	42-52
Study characteristics	17	Cite each included study and present its characteristics.	42-52
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	N/A
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	N/A
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	53-75
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	N/A
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	N/A
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	N/A
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	76-79
	23b	Discuss any limitations of the evidence included in the review.	79-80
	23c	Discuss any limitations of the review processes used.	79-80
	23d	Discuss implications of the results for practice, policy, and future research.	81-82
OTHER INFORMATION			

Section and Topic	Item #	Checklist item	Location where item is reported
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	31
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	31
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	N/A
Competing interests	26	Declare any competing interests of review authors.	N/A
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	N/A

Appendix 2 Protocol for systematic review (10.17605/OSF.IO/4DYUW)

Title: Fidelity of interventions designed to reduce non-indicated imaging for low back pain: a protocol for a systematic review

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Competing interests: None to declare

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Author contributions: All authors took part in the design of the systematic review protocol and reviewed the protocol prior to registration.

Abstract

Background: Intervention fidelity refers to whether an intervention was delivered as intended. Interventions aimed at reducing non-indicated imaging for low back pain (LBP) have shown variable results of effectiveness. However, intervention fidelity has not been previously explored within this context, limiting the interpretation of the findings in these studies.

Objectives: The aim of this systematic review is to review the literature on interventions designed to reduce non-indicated imaging for LBP in order to (1) examine the use of strategies to enhance and/or assess intervention fidelity; (2) report on the psychometric properties of tools used to assess intervention fidelity; and (3) report on the intervention fidelity outcome within evaluations of these interventions.

Methods: Four electronic databases will be searched, with articles screened for inclusion by two reviewers. The National Institutes of Health Behaviour Change Consortium intervention fidelity checklist will be used to assess intervention fidelity across five domains (study design, provider training, delivery of treatment, treatment receipt, and treatment enactment). Intervention fidelity scores, psychometric properties of assessment measures, and intervention fidelity outcomes will be reported.

Discussion: This will be the first review to examine intervention fidelity within studies of interventions aimed at reducing non-indicated imaging for LBP.

Introduction

Intervention fidelity refers to the degree to which an intervention is delivered as intended by the intervention developers (1, 2). Within behaviour change research, intervention fidelity also refers to the methodological strategies used to monitor (e.g., direct observation, audiotapes, self-reported checklists) and enhance (e.g., intervention manual, standardised training) the reliability and validity of behavioural interventions (1-3). Intervention fidelity is an important component in the implementation of complex behavioural change interventions (4) and can influence intervention effectiveness (5), as well as confidence in the results of randomised controlled trials (1).

The National Institutes of Health Behaviour Change Consortium (NIHBCC) developed a framework for intervention fidelity, including five domains: Study Design, Training of Providers, Delivery of Treatment, Receipt of Treatment, and Enactment of Treatment Skills (1). Study Design relates to whether the study adequately tests its hypothesis in relation to an underlying theoretical framework or mechanism of action. Training of Providers relates to the training process of providers, as well as the skills and ability of providers to deliver the intervention. Delivery of Treatment relates to whether the intervention was actually delivered as intended by the intervention developers. Receipt of Treatment relates to the ability of patients to understand and perform the treatment-related skills during the intervention. Enactment of Treatment Skills relates to the ability of the patients to perform the treatment-related skills in real-life settings.

Additionally, the NIHBCC developed a fidelity checklist in 2005 to evaluate intervention fidelity across the five domains in studies of health behaviour change research (2). The checklist has established face validity, as well as inter-rater reliability (2), and has been used in a variety of healthcare settings (6-8). The checklist was updated in 2011 to include items on behavioural theory and multi-cultural considerations (3). The updated checklist includes a total of 40 components for a two-armed trial (44 for three-armed trials and 48 for four-armed trials): 17 (two-armed; 21 for three-armed; 25 for four-armed) in the Study Design domain; seven in the Training of Providers domain; nine in the Delivery of Treatment domain; five in the Receipt of Treatment domain; and two in the Enactment of Treatment Skills domain (3).

Non-specific low back pain (LBP) is a common clinical condition with no pathoanatomical cause of pain (9). As such, diagnostic imaging has limited utility (9) and is not recommended by clinical practice guidelines for the assessment or management of LBP (10, 11). Despite this, imaging continues to be commonly used in clinical practice (12, 13). Interventions that have been used to reduce the use of non-indicated imaging include the distribution of educational materials, clinical decision support tools, modified requisition forms, targeted reminders, and audit and feedback (14-16). Evidence of effectiveness for these interventions has been variable (14-16), and to our knowledge, there has been no comprehensive assessment of intervention fidelity within this context. Without knowledge of intervention fidelity, it is unknown whether the interventions were truly ineffective or if they were ineffective due to poor intervention fidelity. As such, the aim of this systematic review is to review the literature on interventions designed to

reduce non-indicated imaging for LBP in order to (1) examine the use of strategies to enhance and assess intervention fidelity; (2) report on the psychometric properties of tools used to assess intervention fidelity; and (3) report on the intervention fidelity outcome within evaluations of these interventions.

Methods

A systematic review of the literature will be conducted to identify studies of interventions aimed at reducing imaging for LBP. The protocol for this study is designed and reported based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Protocols (PRISMA-P) (17). The protocol for this review will be registered prior to the study start on Open Science Framework.

Data sources and inclusion criteria

This review will update the search strategy of a recent review by our research group that aimed to determine the behaviour change techniques that have been used in interventions to improve adherence to evidence-based LBP imaging and reduce non-indicated imaging for LBP. The review searched MEDLINE (OVID) (Appendix 1), Embase, CINAHL (EBSCO), and the Cochrane Central Register of Controlled Trials from inception to February 2021. Additionally, references from five relevant systematic reviews were hand-searched, forward and backward citation tracking of included studies was conducted, and content experts were consulted. The current review will use the same methodology as reported above to update the search.

Studies will be eligible if they were published in English and meet the inclusion criteria outlined in Table 1.

Studies targeting patients or the public directly (e.g., mass media campaigns) and interventions designed to improve adherence to other aspects of LBP guidelines without targeting imaging will be excluded.

Selection of studies

Results from each database will be combined, duplicates removed, and exported to Covidence (Veritas Health Innovation, Melbourne, Australia) for screening. Two reviewers (DT and RL) will independently screen the titles and abstracts and review full texts for inclusion in the review. At each phase of screening, the reviewers will meet for consensus and any disagreements will be resolved by discussion. If consensus cannot be reached after discussion, a third reviewer (ET) will be consulted to determine eligibility.

Data extraction and risk of bias assessment

Two reviewers (DT and RL) will independently extract data on study characteristics from the included studies (Table 2), including details of: author, year, country, study design, participants, setting, intervention, comparator, and risk of bias. Risk of bias will be assessed using the Cochrane Effective Practice and Organisation of Care tool (18) by the same two reviewers. The two reviewers will also independently extract data on the psychometric properties (i.e., validity and reliability) and outcomes of intervention fidelity assessment measures (Table 3). Any disagreements in data extraction between the

two reviewers will be discussed to consensus, with any persisting discrepancies resolved by a third reviewer (ET).

A codebook, adapted from Toomey et al. (2019) (8), will be developed by one of the authors (DT) to clarify each of the intervention fidelity components in the NIHBCC fidelity checklist. The codebook will be reviewed by a content expert in intervention fidelity (ET) for completeness and accuracy. Prior to data extraction of the intervention fidelity components, two reviewers (DT and RL) will pilot the codebook by independently using the codebook on 10% of the included studies. The reviewers will meet to review their interpretation of the codebook and discuss any discrepancies in coding of the intervention fidelity components. The content expert will be available to address any discrepancies that persist. When both reviewers are confident in their interpretation of the codebook, they will continue with data extraction independently.

Data on intervention fidelity will be extracted for each eligible study by two reviewers (DT and RL) independently using the updated NIHBCC fidelity checklist (3) (Table 4). Each component of the checklist will be scored as: “present” (the study mentions a particular intervention fidelity strategy), corresponding to a score of 1; “absent but should be present” (intervention fidelity information was inappropriately omitted), corresponding to a score of 0; or “not applicable” (the intervention fidelity strategy was not applicable to the study) (2). Authors will be contacted if further information is required. Associated publications for the eligible studies will also be reviewed. The reviewers will meet to review extracted data at two study intervals (i.e., after every two studies). Discrepancies

or disagreements will be resolved through discussion to reach consensus. A third reviewer (ET) will be available to resolve any disagreements that persist. This will allow for the codebook to be updated after coding has begun in order to address any confusion with coding of the intervention fidelity components in the studies. This process will be repeated until data extraction has been completed for all eligible studies.

Data analysis and synthesis

Data on intervention fidelity will be synthesised according to the individual studies, NIHBCC component, and NIHBCC domain, as recommended by the developers (2). For individual studies, intervention fidelity scores will be calculated as the number of components coded as "present" as a proportion of the total number of components deemed "applicable" for that study (Table 5). For each NIHBCC domain, intervention fidelity scores will be calculated as the number of components coded as "present" as a proportion of the total number of components deemed "applicable" for that domain (Table 6). For each NIHBCC component, fidelity scores will be calculated as the number of studies with the component ("present") as a proportion of the total number of studies where that component was deemed "applicable" (Table 7). Intervention fidelity scores will be interpreted as "low" (≤50%), "moderate" (51%-79%), and "high" (≥80%) (3).

Ethics

Not applicable.

Plans for Dissemination

The systematic review will be reported according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) 2020 statement (19). Study results will be disseminated through publication in a peer-reviewed journal.

Discussion

To our knowledge, this will be the first review examining intervention fidelity within studies of interventions aimed at reducing non-indicated imaging for LBP. While many interventions aimed at addressing inappropriate imaging behaviours in primary care practices have been developed and tested, intervention effectiveness has been variable and inappropriate imaging remains common (12). This review on intervention fidelity within these studies may provide some insight into whether or not these interventions have been delivered as intended, allowing for better interpretation of the study results.

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Appendix 3 Search strategy for MEDLINE

1 Primary Health Care/

2 physicians, primary care/

3 primary healthcare.ti,ab.

4 (primary adj2 care).ti,ab.

5 community medicine/

6 community health centers/

7 exp Community Health Services/

8 community.ti,ab.

9 Ambulatory Care/

10 (ambulatory adj (care or setting?)).ti,ab.

11 physicians' offices/

12 clinic?.ti,ab.

13 physicians, family/

14 (family adj (medicine or practice or practitioner? or physician? or doctor?)).ti,ab.

15 general practice/

16 general practitioners/

17 (general adj (practice or practioner?)).ti,ab.

18 (gp or gps).ti,ab.

19 exp Emergency Service, Hospital/

20 Emergency Medicine/

21 (emergency adj2 (department? or unit? or room? or physician?)).ti,ab.

22 (trauma adj2 (centre? or center? or department? or unit?)).ti,ab.

23 (triage adj2 (centre? or center? or department? or unit?)).ti,ab.

24 ("accident and emergency" or "accident & emergency").ti,ab.

25 or/1-24

26 Back Pain/

27 Low Back Pain/

28 (back or backache or backpain).ti,ab.

29 dorsalgia.ti,ab.

30 exp Spine/

31 Lumbosacral Region/

32 exp Spinal Diseases/

33 (lumbar or lumbosacral or 'lumbo sacral' or spine or spinal).ti,ab.

34 or/26-33

35 diagnostic imaging/

36 dg.fs.

37 exp radiography/

38 exp magnetic resonance imaging/

39 exp image interpretation, computer-assisted/

40 imaging.ti,ab.

41 radiograph*.ti,ab.

42 radiolog*.ti,ab.

43 CT.ti,ab.

44 'computed tomography'.ti,ab.

45 ('x ray?' or xray?).ti,ab.

46 (mri or mris).ti,ab.

47 or/35-46

48 quality improvement/

49 program evaluation/

50 (program? or programme?).ti,ab.

51 exp education, continuing/

52 staff development/

53 Inservice Training/

54 ed.fs.

55 (educat* or teach* or train or training or instruction* or learn*).ti,ab.

56 (lecture* or seminar* or presentation* or tutorial* or workshop* or 'work shop' or 'work shops' or webinar*).ti,ab.

57 academic detailing.ti,ab.

58 patient education as topic/

59 exp consumer health information/

60 patient acceptance of healthcare/

61 'patient education'.ti,ab.

62 'consumer health'.ti,ab.

63 exp teaching materials/

64 pamphlets/

65 (leaflet? or booklet? or poster? or pamphlet?).ti,ab.

66 information dissemination/

67 translational medical research/

68 'knowledge translation'.ti,ab.

69 postal service/

70 exp telecommunications/

71 exp mass media/

72 ((written or printed or oral) adj information).ti,ab.

73 ((written or printed or oral) adj communication?).ti,ab.

74 ((media or communication?) adj campaign?).ti,ab.

75 choosing wisely.ti,ab.

76 marketing.ti,ab.

77 practice guidelines as topic/

78 guideline adherence/

79 (guideline? adj2 (adher* or comply* or complies or compliance or disseminat* or distribut*)).ti,ab.

80 (protocol? adj2 (adher* or comply* or complies or compliance or disseminat* or distribut*)).ti,ab.

81 (policy adj2 (change? or changing or modifi* or revise or revised or revision? or update?)).ti,ab.

82 decision support techniques/

83 decision support systems, clinical/

84 reminder systems/

85 'decision support'.ti,ab.

86 reminder?.ti,ab.

87 prompt?.ti,ab.

88 alert?.ti,ab.

89 algorithm?.ti,ab.

90 exp clinical audit/

91 (audit* adj2 (clinical or medical or record? or chart?)).ti,ab.

92 chart review*.ti,ab.

93 feedback/

94 feedback.ti,ab.

95 benchmarking/

96 Attitude of Health Personnel/

97 exp Health Knowledge, Attitudes, Practice/

98 (attitude? adj2 (physician? or resident? or clinician? or provider?)).ti,ab.

99 (belief? adj2 (physician? or resident? or clinician? or provider?)).ti,ab.

100 behavio?ral change?.ti,ab.

101 Practice Patterns, Physicians'/

102 Utilization Review/

103 utili?ation.ti,ab.

104 or/48-103

105 exp medical overuse/

106 (overuse or 'over use').ti,ab.

107 (decreas* adj2 (referral* or imaging or radiograph* or radiolog* or CT or 'computed tomography' or 'x ray?' or xray? or mri or mris)).ti,ab.

108 (reduc* adj2 (referral* or imaging or radiograph* or radiolog* or CT or 'computed tomography' or 'x ray?' or xray? or mri or mris)).ti,ab.

109 (increas* adj2 (referral* or imaging or radiograph* or radiolog* or CT or 'computed tomography' or 'x ray?' or xray? or mri or mris)).ti,ab.

110 (unnecessary adj2 (referral* or imaging or radiograph* or radiolog* or CT or 'computed tomography' or 'x ray?' or xray? or mri or mris)).ti,ab.

111 (appropriate* adj2 (referral* or imaging or radiograph* or radiolog* or CT or 'computed tomography' or 'x ray?' or xray? or mri or mris)).ti,ab.

112 (inappropriate* adj2 (referral* or imaging or radiograph* or radiolog* or CT or 'computed tomography' or 'x ray?' or xray? or mri or mris)).ti,ab.

113 or/106-112

114 exp clinical trial/

115 exp clinical trials as topic/

116 random*.ti,ab.

117 Health Services Research/

118 Comparative Study/

119 Controlled Before-After Studies/

120 Prospective Studies/

121 prospective.ti,ab.

122 (before adj2 after).ti,ab.

123 (pretest adj posttest).ti,ab.

124 pre post test*.ti,ab.

125 pretesting.ti,ab.

126 repeated measurement?.ti,ab.

127 repeated measure?.ti,ab.

128 time series.mp.

129 (control* adj3 (study or design or trial or matched or group)).mp.

130 quasi-experimental.mp.

131 or/114-130

132 25 and 34 and 47 and (104 or 113) and 131

Appendix 4 Codebook to clarify each of the intervention fidelity strategies in the NIHBCC fidelity checklist

The **target behaviour** is changing imaging ordering behaviours of the healthcare providers (i.e., physicians).

The **providers** of the intervention refers to people who will be delivering the intervention (i.e., research team) to the healthcare providers.

The **participants** in the studies/those who will be receiving the intervention are the healthcare providers (i.e., the intervention is targeted at the healthcare providers).

The checklist applies to complex behaviour change interventions aiming directly at physicians to change their imaging ordering behaviours delivered in any modality or format. If interventions have multiple components, each component is scored on the checklist separately.

Llll5x

Five domains – who would be the likely targets of the domain:

Study design – should focus on the intervention design itself

Training – should focus on the providers of the intervention (e.g., research team)

Delivery – should focus on the delivery of the intervention to the physicians by the providers

Receipt – should focus on physicians

Enactment – should focus on the physicians

Domain	Component	Operational definition (with examples)	Type of strategy (Enhancement or Assessment)
Study Design	1) Provide information about dose in the intervention condition		
	a) Length of contact	Length of sessions – e.g., workshop lasted 3 hours each N/A for electronic/automated interventions or for interventions that only had a brief point of contact (e.g., postal dissemination of guideline to physician, giving an educational pamphlet)	Enhancement
	b) Number of contacts	Number of contacts made with physicians – e.g., once (e.g., for electronic interventions); 2 workshops; # of times feedback provided in A&F interventions	Enhancement
	c) Content of intervention	What intervention consisted of/was to consist of – e.g., educational reminder message; workshops were a combination of didactic lectures and small group discussions and activities; guideline that was distributed	Enhancement
	d) Duration of contact over time	Length of overall intervention – e.g., # of sessions over time reported; duration of time feedback period covered (A&F interventions); period of time prompts were provided (for automated interventions with a series of prompts)	Enhancement

		N/A for one-time electronic/automated interventions, policy interventions, one-time postal dissemination of guidelines 0 if the intervention period was not reported	
	2) Provide information about treatment dose in the comparison condition (1 comparison)	Same as 1a) – 1d)	
	a) Length of contact		Enhancement
	b) Number of contacts		Enhancement
	c) Content of treatment		Enhancement
	d) Duration of contact over time		Enhancement
	e) Method to ensure that dose is equivalent between conditions	Only applies if there was a comparison intervention Something that aims to ensure that delivery of dose is equal between intervention and comparison – e.g., treatment manual specifying dose N/A if dose is not meant to be equal	Enhancement
	f) Method to ensure that dose is equivalent for participants within conditions	Only applies if there was a comparison intervention Something that aims to ensure that delivery of dose is equal within intervention and/or within comparison groups – e.g., DVD distributed to all physicians in intervention group (delivering same intervention content and messages) May be 1 for automated interventions – e.g., every physician receives a change in ordering procedure	Enhancement
	2a) Provide information about treatment dose in the comparison condition (2+ comparisons)	As above, only if more than one comparison group used (otherwise, N/A)	
	a) Length of contact		

	b) Number of contacts		
	c) Content of treatment		
	d) Duration of contact over time		
	3) Specification of provider credentials that are needed	Must mention credentials or experience needed to provide intervention/control (including research team) – e.g., radiologist; clinicians with teaching experience; research training background N/A for interventions that do not have a specific provider for the intervention (e.g., postal dissemination of guidelines, policy, automated intervention)	Enhancement
	4) Theoretical model upon which the intervention is based is clearly articulated		
	a) The active ingredients are specified and incorporated into the intervention	Theoretical model must be mentioned and specified/detailed how incorporated into intervention – e.g., social cognitive theory and how aspects of this intervention targeted this theory; "The intervention will consist of a combination of behaviour change techniques. These techniques will be utilised throughout the workshops… These specific techniques have been chosen because they are considered the best approach to address the barriers and enablers to the CPG's implementation" *If active ingredients are specified but not explicitly detailed if incorporated into the intervention, code as 'yes' and add a comment indicating that it was not explicitly detailed if active ingredients were incorporated into the intervention	Enhancement
	b) Use of experts or protocol review group to determine whether the intervention protocol reflects the underlying theoretical model or clinical guidelines	Review team or experts assessed accuracy of intervention components – e.g., use of focus group interviews with physicians to identify constructs relevant to target behaviour; experts in BCTs identifying if intervention included BCTs	Assessment

	c) Plan to ensure that the measures reflect the hypothesized theoretical constructs/mechanisms of action	Outcome measures used should map to hypothesised theoretical constructs – e.g., if hypothesis is reducing healthcare utilisation, that should be measured; if goal was to reduce imaging ordering behaviours by improving self-efficacy of physicians, outcomes for self-efficacy should be measured Only applies to studies which scored a 1 in component 4a)	Enhancement
	5) Potential confounders that limit the ability to make conclusions at the end of the trial are identified	Potential confounders should be acknowledged and identified – e.g., variables such as clinic size, location of practice, number of years in practice, other similar interventions occurring at time of current intervention N/A for study designs that are not RCTs or cluster RCTs	Enhancement
	6) Plan to address possible setbacks in implementation (i.e., backup systems or providers)	Plan for setbacks in implementation – e.g., backup system; DVD provided if physicians cannot attend face-to-face workshop	Enhancement
	7) If more than one intervention is described, all described equally well	If 2+ interventions involved, all should be described equally well Note: This applies to comparison interventions N/A if only one intervention	Enhancement
Training		May be N/A for electronic/automated interventions, A&F interventions (e.g., if interaction did not require a trained human to perform any part of the intervention) *This section looks at the training of the people providing the intervention to the physicians (e.g., research team members)	

	8) Description of how providers will be trained (manual of training procedures)	Must report some information on how people providing the intervention were prepared to do so – e.g., content; method; duration; reference a protocol or manual; describes training of research team	Enhancement
	9) Standardisation of provider training (especially if multiple waves of training are needed for multiple groups of providers)	Must report a method to enhance standardisation of training or enhance the potential for the training to be delivered similarly each time – e.g., training manual; training multiple providers at once N/A if only one provider was used for the entire intervention	Enhancement
	10) Assessment of provider skill acquisition	Any method to assess provider skill acquisition from training – e.g., pre-post assessment of knowledge of intervention after training session	Assessment
	11) Assessment and monitoring of provider skill maintenance over time	Any method to assess and monitor provider skill over the duration of the intervention/trial – e.g., direct observation of sessions; ongoing supervision; ongoing contact with research team; booster sessions	Assessment
	12) Characteristics being sought in a treatment provider are articulated a priori. Characteristics that should be avoided in a treatment provider are articulated a priori	Report what characteristics are sought in a provider – e.g., years of experience; type of experience; knowledge in area	Enhancement
	13) At the hiring stage, assessment of whether or not there is a good fit between the provider and the intervention	Attitudes of provider assessed prior to delivery – e.g., provider acceptability of intervention May be N/A if the providers were not hired, but were just members of the research team	Assessment
	14) There is a training plan that takes into account trainees' different education and experience and learning styles	Plans to tailor training according to provider's experience and learning style – e.g., role plays, verbal and visual delivery styles used	Enhancement
Intervention Delivery	15) Method to ensure that the content of the intervention is delivered as specified	Anything that aims to ensure that intervention is delivered as intended to physicians – e.g., manual with details of intervention content; self-report or reminder checklists	Enhancement

		May be N/A for electronic/automated interventions, electronic A&F interventions	
	16) Method to ensure that the dose of the intervention is delivered as specified	Anything that aims to ensure that intervention is delivered as intended to physicians – e.g., manual with details of intervention dose (such as timing of intervention components); self-report or reminder checklists; checked rate of educational message attachment May be 1 for electronic/automated interventions, electronic A&F interventions – e.g., every physician receives the same change in ordering procedure or same policy applied	Enhancement
	17) Mechanism to assess if the provider actually adhered to the intervention plan or in the case of computer delivered interventions, method to assess participants' contact with the information	Any method to assess provider's actual delivery of the intervention content and/or dose to physicians – e.g., audio recording to assess content; record of attendance is a method of assessing dose Electronic/automated interventions and A&F interventions – any method to assess physician contact with the information – e.g., electronic data; website access records Always relevant	Assessment
	18) Assessment of nonspecific effects of the intervention	Any method to assess provider's actual *quality* of delivery of the intervention – e.g., direct observation; audio/video recording; self-report (evaluating therapeutic alliance) N/A for electronic/automated interventions, electronic A&F interventions, or interventions where there is no direct contact between the provider and physician	Assessment
	19) Use of intervention manual	Treatment manual, protocol, or written instructions to providers used	Enhancement

		N/A for electronic/automated interventions, electronic A&F interventions, or interventions where there is no direct contact between the provider and physician	
	20) There is a plan for the assessment of whether or not the active ingredients were delivered	Any method to assess provider's actual delivery of the *active ingredients* of the intervention – e.g., direct observations; audio/video recording; self-report; whether or not planned BCTs were delivered; how issues with technology were addressed if they occurred Always relevant	Assessment
	21) There is a plan for the assessment of whether or not proscribed components were delivered (e.g., components that are unnecessary or unhelpful)	Any method to assess provider's actual delivery of the intervention *content* – e.g., direct observations; audio/video recording; self-report; if an unintended BCT was delivered; how issues with technology were addressed if they occurred Always relevant *This looks at whether there was an assessment of components of the intervention that should not be provided	Assessment
	22) There is a plan for how will contamination between conditions be prevented	Any method to ensure that intervention group will not contaminate the control group – e.g., cluster randomisation	Enhancement
	23) There is an a priori specification of intervention fidelity	Specification of desired intervention fidelity – e.g., providers adhere to delivering > 80% of components Always relevant	Assessment
Intervention Receipt		May be N/A for electronic/automated interventions and electronic A&F interventions (where there is no interaction between provider and physician)	

	24) There is an assessment of the degree to which participants understood the intervention	Any method to assess physician's understanding of intervention components – e.g., exit questionnaire on understanding; knowledge assessment Always relevant	Assessment
	25) There are specification of strategies that will be used to improve participant comprehension of the intervention	Methods that aim to improve physician's understanding of the intervention – e.g., education sessions, handouts, question and answer, group discussions Always relevant	Enhancement
	26) The participants' ability to perform the intervention skills will be assessed during the intervention period	Any method to assess physician's *ability* to perform the intervention skills or behaviours during the intervention session – e.g., direct observation of physicians discussing why imaging is not indicated during the intervention session May be N/A for electronic/automated interventions and A&F interventions when there is no interaction between the research team and the physician (e.g., if the intervention is not skills-based)	Assessment
	27) A strategy will be used to improve subject performance of intervention skills during the intervention period	Methods aimed to improve physician's ability to perform intervention skills or behaviours during the intervention session – e.g., practical sessions, role play May be N/A for electronic/automated interventions and A&F interventions when there is no interaction between the research team and the physician (e.g., if the intervention is not skills-based)	Enhancement
	28) Multicultural factors considered in the development and delivery of the intervention (e.g., provided in native language; protocol is consistent with the values of the target group)	Handouts provided in local language, participant stakeholders involved in intervention development process – e.g., knowledge of acceptability or satisfaction by physicians Always relevant	Enhancement

Intervention Enactment	29) Participant performance of the intervention skills will be assessed in settings in which the intervention might be applied	Methods to assess physician's performance of intervention skills in the clinic – e.g., physician's imaging ordering behaviours; adherence; communication skills Note: This should be a continued assessment during the time that physicians should be performing the intervention skills. This does NOT refer to outcome measurements (e.g., taken at 6 months post-intervention). N/A for interventions that are not skills-based	Assessment
	30) A strategy will be used to improve performance of the intervention skills in settings in which the intervention might be applied	Methods that aim to improve physician's use of intervention skills in the clinic – e.g., continued reminders, handouts N/A for interventions that are not skills-based	Enhancement

Appendix 5a Reporting of all (applicable) strategies to *enhance fidelity to study design* listed in the NIHBCC checklist for all 50 intervention components

	1a)	1b)	1c)	1d)	2a)	2b)	2c)	2d)	2e)	2f)	3)	4a)	4c)	5)	6)	7)	Fidelity score (%)
Single component interventions																	
Fine (2017)	N/A	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	1	N/A	N/A	75
Fenton (2016)	1	1	1	1	N/A	1	1	N/A	N/A	1	0	0	N/A	N/A	0	1	72.7
French (2013)	1	1	1	1	N/A	1	1	N/A	N/A	1	1	1	1	N/A	1	N/A	100
Winkens (1995)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	1	0	N/A	N/A	0	N/A	66.7
Graves (2018)	N/A	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	1	N/A	N/A	75
Robling (2002a)	0	1	0	1	N/A	1	0	1	N/A	0	0	0	N/A	N/A	0	N/A	40
Robling (2002b) Intervention 1	0	1	1	0	N/A	1	1	N/A	N/A	1	1	0	N/A	N/A	0	0	60
Robling (2002b) Intervention 2	N/A	1	0	N/A	N/A	1	1	N/A	N/A	N/A	N/A	0	N/A	N/A	0	0	42.9
Oakeshott (1994)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	N/A	0	N/A	60
Wang (2018)	1	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	0	0	N/A	1	0	N/A	62.5
Wang (2021) Intervention 1	N/A	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	1	0	1	66.7
Wang (2021) Intervention 2	1	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	0	0	N/A	1	0	1	66.7
Fried (2018)	N/A	1	1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	1	0	N/A	50
Solberg (2010)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	1	0	N/A	66.7
Chen (2020)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	1	0	N/A	66.7
Jarvik (2020)	N/A	1	1	1	N/A	1	1	1	N/A	1	N/A	0	N/A	N/A	0	N/A	77.8
Min (2017)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	1	0	N/A	66.7
Baker (1987)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	0	0	N/A	50
Multi-component interventions																	
Kullgren (2018) a)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	N/A	0	N/A	60

	1a)	1b)	1c)	1d)	2a)	2b)	2c)	2d)	2e)	2f)	3)	4a)	4c)	5)	6)	7)	Fidelity score (%)
Kullgren (2018) b)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	1	0	N/A	N/A	0	N/A	66.7
Kullgren (2018) c)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	1	0	N/A	N/A	0	N/A	66.7
Kullgren (2018) d)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	N/A	0	N/A	60
Lin (2016) a)	1	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	0	1	1	1	0	N/A	77.8
Lin (2016) b)	0	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	0	1	1	1	0	N/A	75
Lin (2016) c)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	1	0	N/A	85.7
Ip (2014) a)	N/A	1	1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	1	0	N/A	50
Ip (2014) b)	0	1	0	0	N/A	N/A	N/A	N/A	N/A	N/A	1	0	N/A	1	0	N/A	42.9
Ip (2014) c)	N/A	1	1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	1	0	N/A	50
Eccles (2001) a)	N/A	1	1	N/A	N/A	1	1	N/A	N/A	0	N/A	0	N/A	N/A	0	N/A	57.1
Eccles (2001) Intervention 1 b)	N/A	1	1	1	N/A	1	1	N/A	N/A	0	N/A	0	N/A	N/A	0	N/A	62.5
Eccles (2001) Intervention 2 b)	N/A	1	1	1	N/A	1	1	N/A	N/A	0	1	0	N/A	N/A	0	N/A	66.7
Kerry (2000) a)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	N/A	0	N/A	60
Kerry (2000) b)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	N/A	0	N/A	60
Morgan (2019) a)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	1	0	N/A	66.7
Morgan (2019) b)	N/A	1	1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	1	0	N/A	50
Morgan (2019) c)	N/A	1	1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	1	0	N/A	50
Zafar (2019) a)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	N/A	0	1	66.7
Zafar (2019) b)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	N/A	0	1	66.7
Klein (2000) a)	N/A	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	0	0	N/A	40
Klein (2000) b)	0	0	1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	0	1	N/A	33.3
Klein (2000) c)	0	1	0	0	N/A	N/A	N/A	N/A	N/A	N/A	0	0	N/A	0	0	N/A	14.3

	1a)	1b)	1c)	1d)	2a)	2b)	2c)	2d)	2e)	2f)	3)	4a)	4c)	5)	6)	7)	Fidelity score (%)
Powell (2019) a)	N/A	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	1	0	N/A	60
Powell (2019) b)	0	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	0	N/A	1	0	N/A	66.7
Freeborn (1997) a)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	1	0	N/A	66.7
Freeborn (1997) b)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	1	0	N/A	66.7
Freeborn (1997) c)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	1	0	N/A	66.7
Tracey (1994) a)	0	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	0	0	N/A	50
Tracey (1994) b)	0	1	1	0	N/A	N/A	N/A	N/A	N/A	N/A	0	0	N/A	0	0	N/A	28.6
Tracey (1994) c)	0	1	1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	0	0	N/A	33.3
Tracey (1994) d)	N/A	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	1	0	N/A	0	0	N/A	57.1
% of intervention components using fidelity strategy	33.3	98	92	73.8	N/A	100	88.9	100	N/A	50	52.9	8.0	100	74.2	4.2	71.4	
Fidelity score: (Number of strategies reported in intervention component / Number of strategies applicable to intervention component) x 100% % of intervention components using fidelity strategy: (Number of intervention components reporting strategy / Number of intervention components the strategy was applicable for) x 100%																	

Appendix 5b Reporting of all (applicable) strategies to *enhance fidelity to provider training* listed in the NIHBCC checklist for all 50 intervention components

	8)	9)	12)	14)	Fidelity score (%)
Single component interventions					
Fine (2017)	N/A	N/A	N/A	N/A	N/A
Fenton (2016)	0	0	0	0	0
French (2013)	0	0	1	0	25
Winkens (1995)	0	0	1	0	25
Graves (2018)	N/A	N/A	N/A	N/A	N/A
Robling (2002a)	0	0	0	0	0
Robling (2002b) Intervention 1	0	0	0	0	0
Robling (2002b) Intervention 2	N/A	N/A	N/A	N/A	N/A
Oakeshott (1994)	N/A	N/A	N/A	N/A	N/A
Wang (2018)	0	0	0	0	0
Wang (2021) Intervention 1	N/A	N/A	N/A	N/A	N/A
Wang (2021) Intervention 2	0	0	0	0	0
Fried (2018)	N/A	N/A	N/A	N/A	N/A
Solberg (2010)	N/A	N/A	N/A	N/A	N/A
Chen (2020)	N/A	N/A	N/A	N/A	N/A
Jarvik (2020)	N/A	N/A	N/A	N/A	N/A
Min (2017)	N/A	N/A	N/A	N/A	N/A
Baker (1987)	N/A	N/A	N/A	N/A	N/A
Multi-component interventions					
Kullgren (2018) a)	N/A	N/A	N/A	N/A	N/A
Kullgren (2018) b)	1	1	0	0	50
Kullgren (2018) c)	1	1	0	0	50
Kullgren (2018) d)	N/A	N/A	N/A	N/A	N/A
Lin (2016) a)	0	0	0	0	0
Lin (2016) b)	0	0	0	0	0
Lin (2016) c)	N/A	N/A	N/A	N/A	N/A
Ip (2014) a)	N/A	N/A	N/A	N/A	N/A

	8)	9)	12)	14)	Fidelity score (%)
Ip (2014) b)	0	0	0	0	0
Ip (2014) c)	N/A	N/A	N/A	N/A	N/A
Eccles (2001) a)	N/A	N/A	N/A	N/A	N/A
Eccles (2001) Intervention 1 b)	N/A	N/A	N/A	N/A	N/A
Eccles (2001) Intervention 2 b)	N/A	N/A	N/A	N/A	N/A
Kerry (2000) a)	N/A	N/A	N/A	N/A	N/A
Kerry (2000) b)	N/A	N/A	N/A	N/A	N/A
Morgan (2019) a)	N/A	N/A	N/A	N/A	N/A
Morgan (2019) b)	N/A	N/A	N/A	N/A	N/A
Morgan (2019) c)	N/A	N/A	N/A	N/A	N/A
Zafar (2019) a)	N/A	N/A	N/A	N/A	N/A
Zafar (2019) b)	N/A	N/A	N/A	N/A	N/A
Klein (2000) a)	N/A	N/A	N/A	N/A	N/A
Klein (2000) b)	0	0	0	0	0
Klein (2000) c)	0	0	0	0	0
Powell (2019) a)	N/A	N/A	N/A	N/A	N/A
Powell (2019) b)	0	0	0	0	0
Freeborn (1997) a)	N/A	N/A	N/A	N/A	N/A
Freeborn (1997) b)	N/A	N/A	N/A	N/A	N/A
Freeborn (1997) c)	N/A	N/A	N/A	N/A	N/A
Tracey (1994) a)	N/A	N/A	N/A	N/A	N/A
Tracey (1994) b)	0	0	0	0	0
Tracey (1994) c)	0	0	0	0	0
Tracey (1994) d)	N/A	N/A	N/A	N/A	N/A
% of intervention components using fidelity strategy	11.8	11.8	11.8	0	
Fidelity score: (Number of strategies reported in intervention component / Number of strategies applicable to intervention component) x 100% % of intervention components using fidelity strategy: (Number of intervention components reporting strategy / Number of intervention components the strategy was applicable for) x 100%					

Appendix 5c Reporting of all (applicable) strategies to *enhance fidelity to intervention delivery* listed in the NIHBCC checklist for all 50 intervention components

	15)	16)	19)	22)	Fidelity score (%)
Single component interventions					
Fine (2017)	0	0	N/A	N/A	0
Fenton (2016)	1	1	0	0	50
French (2013)	1	1	1	1	100
Winkens (1995)	0	0	0	1	25
Graves (2018)	0	0	N/A	N/A	0
Robling (2002a)	0	0	0	1	25
Robling (2002b) Intervention 1	0	0	0	1	25
Robling (2002b) Intervention 2	0	0	N/A	1	33.3
Oakeshott (1994)	0	0	0	1	25
Wang (2018)	0	0	0	N/A	0
Wang (2021) Intervention 1	0	0	N/A	0	0
Wang (2021) Intervention 2	0	0	0	0	0
Fried (2018)	0	0	N/A	N/A	0
Solberg (2010)	1	1	N/A	1	100
Chen (2020)	1	1	N/A	N/A	100
Jarvik (2020)	1	1	N/A	1	100
Min (2017)	0	0	N/A	N/A	0
Baker (1987)	1	1	N/A	N/A	100
Multi-component interventions					
Kullgren (2018) a)	1	1	1	N/A	100
Kullgren (2018) b)	0	0	1	N/A	33.3
Kullgren (2018) c)	0	0	1	N/A	33.3
Kullgren (2018) d)	0	0	N/A	N/A	0
Lin (2016) a)	0	0	0	N/A	0
Lin (2016) b)	0	0	0	N/A	0
Lin (2016) c)	0	0	0	N/A	0
Ip (2014) a)	1	0	N/A	N/A	50

	15)	16)	19)	22)	Fidelity score (%)
Ip (2014) b)	0	0	0	N/A	0
Ip (2014) c)	0	0	N/A	N/A	0
Eccles (2001) a)	0	0	N/A	1	33.3
Eccles (2001) Intervention 1 b)	0	0	N/A	1	33.3
Eccles (2001) Intervention 2 b)	0	1	N/A	1	66.7
Kerry (2000) a)	0	0	N/A	1	33.3
Kerry (2000) b)	0	0	N/A	1	33.3
Morgan (2019) a)	0	0	0	N/A	0
Morgan (2019) b)	1	0	N/A	N/A	50
Morgan (2019) c)	1	0	N/A	N/A	50
Zafar (2019) a)	0	0	N/A	1	33.3
Zafar (2019) b)	1	1	N/A	1	100
Klein (2000) a)	0	0	N/A	N/A	0
Klein (2000) b)	0	0	0	N/A	0
Klein (2000) c)	0	0	0	N/A	0
Powell (2019) a)	1	1	N/A	N/A	100
Powell (2019) b)	0	0	0	N/A	0
Freeborn (1997) a)	1	1	N/A	1	100
Freeborn (1997) b)	1	1	N/A	1	100
Freeborn (1997) c)	1	1	N/A	1	100
Tracey (1994) a)	0	0	N/A	N/A	0
Tracey (1994) b)	0	0	N/A	N/A	0
Tracey (1994) c)	0	0	0	N/A	0
Tracey (1994) d)	0	0	N/A	N/A	0
% of intervention components using fidelity strategy	30	26	20	85.7	
Fidelity score: (Number of strategies reported in intervention component / Number of strategies applicable to intervention component) x 100% % of intervention components using fidelity strategy: (Number of intervention components reporting strategy / Number of intervention components the strategy was applicable for) x 100%					

Appendix 5d Reporting of all (applicable) strategies to *enhance fidelity to intervention receipt* listed in the NIHBCC checklist for all 50 intervention components

	25)	27)	28)	Fidelity score (%)
Single component interventions				
Fine (2017)	0	N/A	0	0
Fenton (2016)	0	1	0	33.3
French (2013)	1	1	0	66.7
Winkens (1995)	0	N/A	0	0
Graves (2018)	0	N/A	0	0
Robling (2002a)	0	N/A	0	0
Robling (2002b) Intervention 1	1	N/A	0	50
Robling (2002b) Intervention 2	1	N/A	0	50
Oakeshott (1994)	0	N/A	0	0
Wang (2018)	0	N/A	0	0
Wang (2021) Intervention 1	0	N/A	0	0
Wang (2021) Intervention 2	0	N/A	0	0
Fried (2018)	0	N/A	0	0
Solberg (2010)	0	N/A	0	0
Chen (2020)	0	N/A	0	0
Jarvik (2020)	0	N/A	0	0
Min (2017)	1	N/A	0	50
Baker (1987)	0	N/A	0	0
Multi-component interventions				
Kullgren (2018) a)	0	N/A	0	0
Kullgren (2018) b)	0	N/A	0	0
Kullgren (2018) c)	0	N/A	0	0
Kullgren (2018) d)	0	N/A	0	0
Lin (2016) a)	0	1	0	33.3
Lin (2016) b)	0	N/A	0	0
Lin (2016) c)	0	N/A	0	0
Ip (2014) a)	1	N/A	0	50

	25)	27)	28)	Fidelity score (%)
Ip (2014) b)	0	N/A	0	0
Ip (2014) c)	0	N/A	0	0
Eccles (2001) a)	0	N/A	0	0
Eccles (2001) Intervention 1 b)	0	N/A	0	0
Eccles (2001) Intervention 2 b)	0	N/A	0	0
Kerry (2000) a)	0	N/A	0	0
Kerry (2000) b)	0	N/A	0	0
Morgan (2019) a)	1	N/A	0	50
Morgan (2019) b)	0	0	0	0
Morgan (2019) c)	0	N/A	0	0
Zafar (2019) a)	0	N/A	0	0
Zafar (2019) b)	1	N/A	0	50
Klein (2000) a)	1	N/A	0	50
Klein (2000) b)	0	N/A	0	0
Klein (2000) c)	0	N/A	0	0
Powell (2019) a)	1	N/A	0	50
Powell (2019) b)	0	N/A	0	0
Freeborn (1997) a)	1	N/A	0	50
Freeborn (1997) b)	0	N/A	0	0
Freeborn (1997) c)	1	N/A	0	50
Tracey (1994) a)	0	N/A	0	0
Tracey (1994) b)	0	0	0	0
Tracey (1994) c)	0	N/A	0	0
Tracey (1994) d)	0	N/A	0	0
% of intervention components using fidelity strategy	22	60	0	
Fidelity score: (Number of strategies reported in intervention component / Number of strategies applicable to intervention component) x 100% % of intervention components using fidelity strategy: (Number of intervention components reporting strategy / Number of intervention components the strategy was applicable for) x 100%				

Appendix 5e Reporting of all (applicable) strategies to *enhance fidelity to intervention enactment* listed in the NIHBCC checklist for all 50 intervention components

	30)	Fidelity score (%)
Single component interventions		
Fine (2017)	N/A	N/A
Fenton (2016)	0	0
French (2013)	0	0
Winkens (1995)	N/A	N/A
Graves (2018)	N/A	N/A
Robling (2002a)	N/A	N/A
Robling (2002b) Intervention 1	N/A	N/A
Robling (2002b) Intervention 2	N/A	N/A
Oakeshott (1994)	N/A	N/A
Wang (2018)	N/A	N/A
Wang (2021) Intervention 1	N/A	N/A
Wang (2021) Intervention 2	N/A	N/A
Fried (2018)	N/A	N/A
Solberg (2010)	N/A	N/A
Chen (2020)	N/A	N/A
Jarvik (2020)	N/A	N/A
Min (2017)	N/A	N/A
Baker (1987)	N/A	N/A
Multi-component interventions		
Kullgren (2018) a)	N/A	N/A
Kullgren (2018) b)	N/A	N/A
Kullgren (2018) c)	N/A	N/A
Kullgren (2018) d)	N/A	N/A
Lin (2016) a)	0	0
Lin (2016) b)	N/A	N/A
Lin (2016) c)	N/A	N/A
Ip (2014) a)	N/A	N/A

	30)	Fidelity score (%)
Ip (2014) b)	N/A	N/A
Ip (2014) c)	N/A	N/A
Eccles (2001) a)	N/A	N/A
Eccles (2001) Intervention 1 b)	N/A	N/A
Eccles (2001) Intervention 2 b)	N/A	N/A
Kerry (2000) a)	N/A	N/A
Kerry (2000) b)	N/A	N/A
Morgan (2019) a)	N/A	N/A
Morgan (2019) b)	0	0
Morgan (2019) c)	N/A	N/A
Zafar (2019) a)	N/A	N/A
Zafar (2019) b)	N/A	N/A
Klein (2000) a)	N/A	N/A
Klein (2000) b)	N/A	N/A
Klein (2000) c)	N/A	N/A
Powell (2019) a)	N/A	N/A
Powell (2019) b)	N/A	N/A
Freeborn (1997) a)	N/A	N/A
Freeborn (1997) b)	N/A	N/A
Freeborn (1997) c)	N/A	N/A
Tracey (1994) a)	N/A	N/A
Tracey (1994) b)	0	0
Tracey (1994) c)	N/A	N/A
Tracey (1994) d)	N/A	N/A
% of intervention components using fidelity strategy	0	
Fidelity score: (Number of strategies reported in intervention component / Number of strategies applicable to intervention component) x 100% % of intervention components using fidelity strategy: (Number of intervention components reporting strategy / Number of intervention components the strategy was applicable for) x 100%		

Appendix 5f Reporting of all (applicable) strategies to *assess fidelity to study design* listed in the NIHBCC checklist for all 50 intervention components

	4b)	Fidelity score (%)
Single component interventions		
Fine (2017)	0	0
Fenton (2016)	1	100
French (2013)	1	100
Winkens (1995)	1	100
Graves (2018)	1	100
Robling (2002a)	0	0
Robling (2002b) Intervention 1	0	0
Robling (2002b) Intervention 2	0	0
Oakeshott (1994)	0	0
Wang (2018)	0	0
Wang (2021) Intervention 1	0	0
Wang (2021) Intervention 2	0	0
Fried (2018)	0	0
Solberg (2010)	0	0
Chen (2020)	0	0
Jarvik (2020)	0	0
Min (2017)	1	100
Baker (1987)	0	0
Multi-component interventions		
Kullgren (2018) a)	0	0
Kullgren (2018) b)	0	0
Kullgren (2018) c)	0	0
Kullgren (2018) d)	0	0
Lin (2016) a)	0	0
Lin (2016) b)	0	0
Lin (2016) c)	0	0
Ip (2014) a)	0	0

	4b)	Fidelity score (%)
Ip (2014) b)	0	0
Ip (2014) c)	0	0
Eccles (2001) a)	0	0
Eccles (2001) Intervention 1 b)	0	0
Eccles (2001) Intervention 2 b)	0	0
Kerry (2000) a)	0	0
Kerry (2000) b)	0	0
Morgan (2019) a)	0	0
Morgan (2019) b)	0	0
Morgan (2019) c)	1	100
Zafar (2019) a)	0	0
Zafar (2019) b)	0	0
Klein (2000) a)	0	0
Klein (2000) b)	0	0
Klein (2000) c)	0	0
Powell (2019) a)	0	0
Powell (2019) b)	0	0
Freeborn (1997) a)	0	0
Freeborn (1997) b)	0	0
Freeborn (1997) c)	0	0
Tracey (1994) a)	0	0
Tracey (1994) b)	0	0
Tracey (1994) c)	0	0
Tracey (1994) d)	0	0
% of intervention components using fidelity strategy	12	
Fidelity score: (Number of strategies reported in intervention component / Number of strategies applicable to intervention component) x 100% % of intervention components using fidelity strategy: (Number of intervention components reporting strategy / Number of intervention components the strategy was applicable for) x 100%		

Appendix 5g Reporting of all (applicable) strategies to *assess fidelity to provider training* listed in the NIHBCC checklist for all 50 intervention components

	10)	11)	13)	Fidelity score (%)
Single component interventions				
Fine (2017)	N/A	N/A	N/A	N/A
Fenton (2016)	0	1	0	33.3
French (2013)	0	0	0	0
Winkens (1995)	0	0	0	0
Graves (2018)	N/A	N/A	N/A	N/A
Robling (2002a)	0	0	0	0
Robling (2002b) Intervention 1	0	0	N/A	0
Robling (2002b) Intervention 2	N/A	N/A	N/A	N/A
Oakeshott (1994)	N/A	N/A	N/A	N/A
Wang (2018)	0	0	0	0
Wang (2021) Intervention 1	N/A	N/A	N/A	N/A
Wang (2021) Intervention 2	0	N/A	N/A	0
Fried (2018)	N/A	N/A	N/A	N/A
Solberg (2010)	N/A	N/A	N/A	N/A
Chen (2020)	N/A	N/A	N/A	N/A
Jarvik (2020)	N/A	N/A	N/A	N/A
Min (2017)	N/A	N/A	N/A	N/A
Baker (1987)	N/A	N/A	N/A	N/A
Multi-component interventions				
Kullgren (2018) a)	N/A	N/A	N/A	N/A
Kullgren (2018) b)	0	0	0	0
Kullgren (2018) c)	0	0	0	0
Kullgren (2018) d)	N/A	N/A	N/A	N/A
Lin (2016) a)	0	0	N/A	0
Lin (2016) b)	0	0	N/A	0
Lin (2016) c)	N/A	N/A	N/A	N/A
Ip (2014) a)	N/A	N/A	N/A	N/A

	10)	11)	13)	Fidelity score (%)
Ip (2014) b)	0	0	0	0
Ip (2014) c)	N/A	N/A	N/A	N/A
Eccles (2001) a)	N/A	N/A	N/A	N/A
Eccles (2001) Intervention 1 b)	N/A	N/A	N/A	N/A
Eccles (2001) Intervention 2 b)	N/A	N/A	N/A	N/A
Kerry (2000) a)	N/A	N/A	N/A	N/A
Kerry (2000) b)	N/A	N/A	N/A	N/A
Morgan (2019) a)	N/A	N/A	N/A	N/A
Morgan (2019) b)	N/A	N/A	N/A	N/A
Morgan (2019) c)	N/A	N/A	N/A	N/A
Zafar (2019) a)	N/A	N/A	N/A	N/A
Zafar (2019) b)	N/A	N/A	N/A	N/A
Klein (2000) a)	N/A	N/A	N/A	N/A
Klein (2000) b)	0	0	N/A	0
Klein (2000) c)	0	0	0	0
Powell (2019) a)	N/A	N/A	N/A	N/A
Powell (2019) b)	0	0	0	0
Freeborn (1997) a)	N/A	N/A	N/A	N/A
Freeborn (1997) b)	N/A	N/A	N/A	N/A
Freeborn (1997) c)	N/A	N/A	N/A	N/A
Tracey (1994) a)	N/A	N/A	N/A	N/A
Tracey (1994) b)	0	0	0	0
Tracey (1994) c)	0	0	0	0
Tracey (1994) d)	N/A	N/A	N/A	N/A
% of intervention components using fidelity strategy	0	6.3	0	
Fidelity score: (Number of strategies reported in intervention component / Number of strategies applicable to intervention component) x 100% % of intervention components using fidelity strategy: (Number of intervention components reporting strategy / Number of intervention components the strategy was applicable for) x 100%				

Appendix 5h Reporting of all (applicable) strategies to *assess fidelity to intervention delivery* listed in the NIHBCC checklist for all 50 intervention components

	17)	18)	20)	21)	23)	Fidelity score (%)
Single component interventions						
Fine (2017)	0	N/A	0	0	0	0
Fenton (2016)	1	1	0	0	0	40
French (2013)	1	1	1	0	0	60
Winkens (1995)	0	0	0	0	0	0
Graves (2018)	0	N/A	0	0	0	0
Robling (2002a)	0	0	0	0	0	0
Robling (2002b) Intervention 1	0	0	0	0	0	0
Robling (2002b) Intervention 2	0	N/A	0	0	0	0
Oakeshott (1994)	0	N/A	0	0	0	0
Wang (2018)	0	0	0	0	0	0
Wang (2021) Intervention 1	0	N/A	0	0	0	0
Wang (2021) Intervention 2	0	0	0	0	0	0
Fried (2018)	0	N/A	0	0	0	0
Solberg (2010)	0	N/A	0	0	0	0
Chen (2020)	1	N/A	0	0	0	25
Jarvik (2020)	0	N/A	1	0	0	25
Min (2017)	0	N/A	0	0	0	0
Baker (1987)	1	N/A	0	0	0	25
Multi-component interventions						
Kullgren (2018) a)	1	N/A	0	0	0	25
Kullgren (2018) b)	0	N/A	0	0	0	0
Kullgren (2018) c)	0	N/A	0	0	0	0
Kullgren (2018) d)	0	N/A	0	0	0	0
Lin (2016) a)	0	0	0	0	0	0
Lin (2016) b)	0	0	0	0	0	0
Lin (2016) c)	0	0	0	0	0	0
Ip (2014) a)	1	N/A	0	0	0	25

	17)	18)	20)	21)	23)	Fidelity score (%)
Ip (2014) b)	0	0	0	0	0	0
Ip (2014) c)	0	N/A	0	0	0	0
Eccles (2001) a)	0	N/A	0	0	0	0
Eccles (2001) Intervention 1 b)	0	N/A	0	0	0	0
Eccles (2001) Intervention 2 b)	0	N/A	0	0	0	0
Kerry (2000) a)	1	N/A	0	0	0	25
Kerry (2000) b)	0	N/A	0	0	0	0
Morgan (2019) a)	0	N/A	0	0	0	0
Morgan (2019) b)	0	N/A	0	0	0	0
Morgan (2019) c)	0	N/A	0	0	0	0
Zafar (2019) a)	0	N/A	0	0	0	0
Zafar (2019) b)	0	N/A	0	0	0	0
Klein (2000) a)	0	N/A	0	0	0	0
Klein (2000) b)	0	0	0	0	0	0
Klein (2000) c)	0	0	0	0	0	0
Powell (2019) a)	0	N/A	0	0	0	0
Powell (2019) b)	0	0	0	0	0	0
Freeborn (1997) a)	1	N/A	0	0	0	25
Freeborn (1997) b)	1	N/A	0	0	0	25
Freeborn (1997) c)	1	N/A	0	0	0	25
Tracey (1994) a)	0	N/A	0	0	0	0
Tracey (1994) b)	0	N/A	0	0	0	0
Tracey (1994) c)	0	0	0	0	0	0
Tracey (1994) d)	0	N/A	0	0	0	0
% of intervention components using fidelity strategy	20	13.3	4	0	0	
Fidelity score: (Number of strategies reported in intervention component / Number of strategies applicable to intervention component) x 100% % of intervention components using fidelity strategy: (Number of intervention components reporting strategy / Number of intervention components the strategy was applicable for) x 100%						

Appendix 5i Reporting of all (applicable) strategies to *assess fidelity to intervention receipt* listed in the NIHBCC checklist for all 50 intervention components

	24)	26)	Fidelity score (%)
Single component interventions			
Fine (2017)	0	N/A	0
Fenton (2016)	0	0	0
French (2013)	1	0	50
Winkens (1995)	0	N/A	0
Graves (2018)	0	N/A	0
Robling (2002a)	0	N/A	0
Robling (2002b) Intervention 1	0	N/A	0
Robling (2002b) Intervention 2	0	N/A	0
Oakeshott (1994)	0	N/A	0
Wang (2018)	0	N/A	0
Wang (2021) Intervention 1	0	N/A	0
Wang (2021) Intervention 2	0	N/A	0
Fried (2018)	0	N/A	0
Solberg (2010)	0	N/A	0
Chen (2020)	0	N/A	0
Jarvik (2020)	0	N/A	0
Min (2017)	0	N/A	0
Baker (1987)	0	N/A	0
Multi-component interventions			
Kullgren (2018) a)	N/A	N/A	0
Kullgren (2018) b)	0	N/A	0
Kullgren (2018) c)	0	N/A	0
Kullgren (2018) d)	0	N/A	0
Lin (2016) a)	1	0	50
Lin (2016) b)	1	N/A	100
Lin (2016) c)	1	N/A	100
Ip (2014) a)	0	N/A	0

	24)	26)	Fidelity score (%)
Ip (2014) b)	0	N/A	0
Ip (2014) c)	0	N/A	0
Eccles (2001) a)	0	N/A	0
Eccles (2001) Intervention 1 b)	0	N/A	0
Eccles (2001) Intervention 2 b)	0	N/A	0
Kerry (2000) a)	0	N/A	0
Kerry (2000) b)	0	N/A	0
Morgan (2019) a)	0	N/A	0
Morgan (2019) b)	0	0	0
Morgan (2019) c)	0	N/A	0
Zafar (2019) a)	0	N/A	0
Zafar (2019) b)	0	N/A	0
Klein (2000) a)	0	N/A	0
Klein (2000) b)	0	N/A	0
Klein (2000) c)	0	N/A	0
Powell (2019) a)	0	N/A	0
Powell (2019) b)	0	N/A	0
Freeborn (1997) a)	0	N/A	0
Freeborn (1997) b)	0	N/A	0
Freeborn (1997) c)	0	N/A	0
Tracey (1994) a)	0	N/A	0
Tracey (1994) b)	0	0	0
Tracey (1994) c)	0	N/A	0
Tracey (1994) d)	0	N/A	0
% of intervention components using fidelity strategy	8.2	0	
Fidelity score: (Number of strategies reported in intervention component / Number of strategies applicable to intervention component) x 100% % of intervention components using fidelity strategy: (Number of intervention components reporting strategy / Number of intervention components the strategy was applicable for) x 100%			

Appendix 5j Reporting of all (applicable) strategies to *assess fidelity to intervention enactment* listed in the NIHBCC checklist for all 50 intervention components

	29)	Fidelity score (%)
Single component interventions		
Fine (2017)	N/A	N/A
Fenton (2016)	1	100
French (2013)	0	0
Winkens (1995)	N/A	N/A
Graves (2018)	N/A	N/A
Robling (2002a)	N/A	N/A
Robling (2002b) Intervention 1	N/A	N/A
Robling (2002b) Intervention 2	N/A	N/A
Oakeshott (1994)	N/A	N/A
Wang (2018)	N/A	N/A
Wang (2021) Intervention 1	N/A	N/A
Wang (2021) Intervention 2	N/A	N/A
Fried (2018)	N/A	N/A
Solberg (2010)	N/A	N/A
Chen (2020)	N/A	N/A
Jarvik (2020)	N/A	N/A
Min (2017)	N/A	N/A
Baker (1987)	N/A	N/A
Multi-component interventions		
Kullgren (2018) a)	N/A	N/A
Kullgren (2018) b)	N/A	N/A
Kullgren (2018) c)	N/A	N/A
Kullgren (2018) d)	N/A	N/A
Lin (2016) a)	0	0
Lin (2016) b)	N/A	N/A
Lin (2016) c)	N/A	N/A
Ip (2014) a)	N/A	N/A

	29)	Fidelity score (%)
Ip (2014) b)	N/A	N/A
Ip (2014) c)	N/A	N/A
Eccles (2001) a)	N/A	N/A
Eccles (2001) Intervention 1 b)	N/A	N/A
Eccles (2001) Intervention 2 b)	N/A	N/A
Kerry (2000) a)	N/A	N/A
Kerry (2000) b)	N/A	N/A
Morgan (2019) a)	N/A	N/A
Morgan (2019) b)	0	0
Morgan (2019) c)	N/A	N/A
Zafar (2019) a)	N/A	N/A
Zafar (2019) b)	N/A	N/A
Klein (2000) a)	N/A	N/A
Klein (2000) b)	N/A	N/A
Klein (2000) c)	N/A	N/A
Powell (2019) a)	N/A	N/A
Powell (2019) b)	N/A	N/A
Freeborn (1997) a)	N/A	N/A
Freeborn (1997) b)	N/A	N/A
Freeborn (1997) c)	N/A	N/A
Tracey (1994) a)	N/A	N/A
Tracey (1994) b)	0	0
Tracey (1994) c)	N/A	N/A
Tracey (1994) d)	N/A	N/A
% of intervention components using fidelity strategy	20	
Fidelity score: (Number of strategies reported in intervention component / Number of strategies applicable to intervention component) x 100% % of intervention components using fidelity strategy: (Number of intervention components reporting strategy / Number of intervention components the strategy was applicable for) x 100%		

Appendix 6 COnsolidated criteria for Reporting Qualitative research (COREQ) checklist

A checklist of items that should be included in reports of qualitative research. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Topic	Item No.	Guide Questions/Description	Reported on Page No.
Domain 1: Research team and reflexivity			
Personal characteristics			
Interviewer/Facilitator	1	Which author/s conducted the interview or focus group?	90-91
Credentials	2	What were the researcher's credentials? E.g. PhD, MD	90-91
Occupation	3	What was their occupation at the time of the study?	90-91
Gender	4	Was the researcher male or female?	N/A
Experience and training	5	What experience or training did the researcher have?	90-91
Relationship with participants			
Relationship established	6	Was a relationship established prior to study commencement?	90-91
Participant knowledge of the interviewer	7	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	90-91
Interviewer characteristics	8	What characteristics were reported about the inter viewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	90-91
Domain 2: Study design			
Theoretical framework			
Methodological orientation and Theory	9	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	92
Participant selection			
Sampling	10	How were participants selected? e.g. purposive, convenience, consecutive, snowball	89-90
Method of approach	11	How were participants approached? e.g. face-to-face, telephone, mail, email	89-90
Sample size	12	How many participants were in the study?	95

Non-participation	13	How many people refused to participate or dropped out? Reasons?	95
Setting			
Setting of data collection	14	Where was the data collected? e.g. home, clinic, workplace	95
Presence of non-participants	15	Was anyone else present besides the participants and researchers?	91
Description of sample	16	What are the important characteristics of the sample? e.g. demographic data, date	95
Data collection			
Interview guide	17	Were questions, prompts, guides provided by the authors? Was it pilot tested?	91-92
Repeat interviews	18	Were repeat inter views carried out? If yes, how many?	95
Audio/visual recording	19	Did the research use audio or visual recording to collect the data?	91
Field notes	20	Were field notes made during and/or after the inter view or focus group?	91
Duration	21	What was the duration of the inter views or focus group?	95
Data saturation	22	Was data saturation discussed?	90, 95
Transcripts returned	23	Were transcripts returned to participants for comment and/or correction?	95
Domain 3: Analysis and findings			
Data analysis			
Number of data coders	24	How many data coders coded the data?	92-94
Description of the coding tree	25	Did authors provide a description of the coding tree?	Appendix 8
Derivation of themes	26	Were themes identified in advance or derived from the data?	92-94
Software	27	What software, if applicable, was used to manage the data?	92
Participant checking	28	Did participants provide feedback on the findings?	95
Reporting			
Quotations presented	29	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g. participant number	Table 4.1-4.4
Data and findings consistent	30	Was there consistency between the data presented and the findings?	96-108
Clarity of major themes	31	Were major themes clearly presented in the findings?	96-99, 105-108
Clarity of minor themes	32	Is there a description of diverse cases or discussion of minor themes?	99, 108
Developed from: Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. International Journal for Quality in Health Care. 2007. Volume 19, Number 6: pp. 349 – 357			

Appendix 7 Interview guide mapped to the NIHBCC intervention fidelity checklist

Demographic questions:
Profession: GP or Chiropractor
Location: Urban or Rural
Number of years in practice:

Part 1 Discussion of intervention fidelity and the proposed intervention

Presentation

- Presentation on intervention fidelity (what it is and why it is important)
- Explain the aim of today's interview
- Introduce the proposed intervention (clinical resource) and explain its goals

Discussion

Questions	NIHBCC Intervention Fidelity Checklist (Borrelli 2005, 2011)
Do you think non-indicated imaging for LBP is an important issue? • Follow up: Do you think an intervention to reduce non-indicated imaging for LBP is important?	Characteristics being sought in a treatment provider are articulated a priori (*Training*) Assessment of whether or not there is a good fit between the provider and the intervention (*Training*)
What do you think about this clinical resource? • Prompt: Is it good/bad? Will it be useful/not useful?	Assessment of whether or not there is a good fit between the provider and the intervention (*Training*)
What is your level of knowledge about imaging and LBP? • Prompt: Knowledge about guidelines and other evidence	Characteristics being sought in a treatment provider are articulated a priori (*Training*) Assessment of whether or not there is a good fit between the provider and the intervention (*Training*) There is a training plan that takes into account trainees' different education and experience and learning styles (*Training*)
What impact do you think an intervention like this will have on your patients? • Prompt: Like it /hate it/not really notice a change?	Not in checklist – Provider's perception on *Receipt* and *Enactment*

<u>Part 2</u> Fidelity of training

Presentation

- Present general strategies for enhancing and monitoring fidelity of *training*, as well as proposed strategies to be used in the study

Discussion

Questions	NIHBCC Intervention Fidelity Checklist (Borrelli 2005, 2011)
What do you think about some of the potential strategies for ensuring intervention fidelity related to your training to use this clinical resource? • Follow up: How do you feel they might work or not work for you? Why or why not?	There is a training plan that takes into account trainees' different education and experience and learning styles
Do you think having a training manual will be helpful for your training? • Follow up: What are some key things you would like to have in the training manual? What about formatting – paper or as a PDF? • Follow up: Are there other things you need to know/learn about in order to be properly trained in using the intervention? • Follow up: Are there other skills you think you need in order to be properly trained in the using the intervention?	Description of how providers will be trained (manual of training procedures) Standardisation of provider training
Do you think regular booster sessions and/or support from the research team would be helpful? Why or why not? • Follow up: What do you think would be the best way to provide support?	Monitoring of provider skill maintenance over time
What assessment strategies do you feel would be useful to help make sure you have acquired all the skills for delivering the intervention?	Assessment of provider skill acquisition Assessment and monitoring of provider skill maintenance over time

• Prompt: role play, pre- and post-testing, monitoring of encounters through audio recording	
What challenges can you see with respect to being able to attend the training session? What resources would you need to help overcome these challenges? • Prompt: location, time, in-person format	Not in checklist – Goal of question: Finding out what providers need in order to achieve high fidelity of training (e.g., being able to actually attend the sessions)

Part 3 Fidelity of intervention delivery

Presentation

- Present general strategies for enhancing and monitoring fidelity of *intervention delivery*, as well as proposed strategies to be used in the study

Discussion

Questions	NIHBCC Intervention Fidelity Checklist (Borrelli 2005, 2011)
What do you think about some of the potential strategies for ensuring intervention fidelity related to using this clinical resource in your practice? • Follow up: How do you feel they might work or not work for you? Why or why not? • Follow up: How do you feel about using audio recording to ensure adherence to protocol?	Method to ensure that the content of the intervention is delivered as specified Mechanism to assess if the provider actually adhered to the intervention plan
Do you think having a script or manual for using the clinical resource will help you to better deliver the intervention to your patients?	Method to ensure that the content of the intervention is delivered as specified Use of treatment manual
How easy or difficult do you think it would be to adhere to delivering >80% of the intervention components?	There is an a priori specification of treatment fidelity (e.g., providers adhere to delivering >80% of components)

• Follow up: What aspects of the intervention seem easy? What ones seem more difficult to deliver? And why? • Follow up: What other things do you need to know/learn in order to deliver the intervention? • Follow up: What other skills do you need in order to deliver the intervention?	
What challenges related to resources can you see with respect to being able to deliver the intervention? • Follow up: What do you need to help overcome these challenges? • Prompt: time, equipment, knowledge	Not in checklist – Goal of question: Finding out what providers need in order to achieve high fidelity of intervention delivery (e.g., being able to actually deliver the intervention)
What challenges related to patient factors do you think might influence your ability to deliver the intervention?	Not in checklist – Goal of question: Finding out what providers need in order to achieve high fidelity of intervention delivery (e.g., being able to actually deliver the intervention)
How important is it for you to deliver this intervention as planned? • Follow up: What components of the intervention do you think needs to be more flexible/adaptable?	Not in checklist – Goal of question: For intervention planning

Leading up to this interview, was there anything that you expected to talk about today that we didn't discuss?

Conclusion

Could you please provide us (now or emailed to us at a later date) with two other practitioners who you think may be interested in participating in the study? We are looking for those from different geographical regions, as well as those who may have differing views or practice patterns to ensure a wide range of perspectives are captured in our study.

Appendix 8 Codebook for each domain in the Theoretical Domains Framework

Target behaviour: Being trained in and delivering an intervention to reduce imaging for LBP with high fidelity

Domain	Definition, question, component constructs	Examples	Rationale
Knowledge	An awareness of the existence of something **What do they know about imaging and LBP?** **How does that influence their training in using the intervention?** **How does that influence if they can/will deliver the intervention as planned?** • Knowledge of condition/scientific rationale • Procedural knowledge • Knowledge of task environment	Q: In terms of your level of knowledge about imaging and back pain, where do you get your knowledge? A: I think it was very much a fundamental part of our radiology training in school – to ensure that unnecessary imaging was not part of your clinical practice. Q: Are you aware of clinical practice or professional guidelines for back pain? A: Yes. We don't have an official document, but that sentiment and that education will be reiterated regularly in our provided CE. There is a mandatory ongoing continuing education component for radiology.	Participant has knowledge about LBP and imaging. This can imply a good fit between the provider and the intervention.
Skills	An ability or proficiency acquired through practice	I do find with patients when I take the time to explain to them that, not just from a radiation perspective, but that	Participant uses communication skills to educate the patient about LBP and imaging. This can imply a

	What do they know about how to manage LBP without imaging? **How does that influence their training in using the intervention?** **How does that influence if they can/will deliver the intervention as planned?** • Skills • Skills development • Competence • Ability • Interpersonal skills • Practice • Skill assessment	it won't affect what we do, they're very reasonable about [not having imaging for LBP]. I do think patients, when you take the time to actually educate them on it, they're very receptive to not getting the image that they might have initially come to pursue at the beginning of the appointment.	good fit between the provider and the intervention.
Social/professional role and identity	A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting **Do they think it is their role as a healthcare provider and/or participant in the study to be adequately trained in how to use the intervention?** **Do they think it is their role as a healthcare provider and/or participant in the study to deliver the intervention as planned?** • Professional identity	It's always good to have your skills honed. It's an uncomfortable thing, of course, to be taped, or especially at a certain point in your practice to feel you're being evaluated in these things that you would like to think you're quite proficient in. But none of us are proficient in everything every day. Hence, commitment to lifelong learning. I don't think it's a farfetched thing. I think it's something that's pretty fundamental to our daily practice.	Participant feels that it is their role to constantly review their skills.

	• Professional role • Social identity • Identity • Professional boundaries • Professional confidence • Group identity • Leadership • Organisational commitment	I do feel that this stuff gives back to your whole profession and it gives back to your patient's best interest. So, I think appealing to people in that regard would certainly invoke more of a commitment to doing it [participating in the study].	Participant feels it is their role to participate in the study.
Beliefs about capabilities	Acceptance of the truth, reality, or validity **about an ability**, talent, or facility that a person can put to constructive use **How confident are they in being able to be trained in using the intervention?** **How confident are they in delivering the intervention as planned?** **Is it up to them whether they can be trained or deliver the intervention? (Perceived control)** • Self-confidence • Perceived competence • Self-efficacy • Perceived behavioural control • Beliefs • Self-esteem	I think it's something we should be fairly comfortable in participating in to improve.	Participant has confidence in being able to deliver the intervention.

	• Empowerment • Professional confidence		
Optimism	The confidence that things will happen for the best or that desired goals will be attained **How does whether they are optimistic/pessimistic influence their training in using the intervention?** **How does whether they are optimistic/pessimistic influence whether they can/will deliver the intervention as intended?** • Optimism • Pessimism • Unrealistic optimism • Identity	Q: Do you think this intervention would actually be helpful in reducing imaging by practitioners? A: I do. Q: What do you think about this specific clinical resource – do you think it's good or bad? A: I think it'll be very good. I think that a booklet of some sort that you can give to a patient would be very effective. Q: Do you think people would not like to be audiotaped? A: I think that people would buy into it.	Participant is optimistic about the intervention.
Beliefs about consequences	Acceptance of the truth, reality, or validity about outcomes of a behaviour in a given situation **What will happen to them (their patients, their organisation, etc.) if they are trained in the intervention?** **What will happen to them (their patients, their organisation, etc.) if they deliver the intervention as intended?**	It's an uncomfortable thing, of course, to be taped. I think that this would actually help to expedite an appointment in real practice.	Negative consequence of assessing fidelity (feeling uncomfortable). Positive consequence of delivering the intervention as planned.

	• Beliefs • Outcome expectancies • Characteristics of outcome • expectancies • Anticipated regret • Consequents		
Reinforcement	Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus **How will their previous experiences of managing LBP without imaging influence their training in using the intervention?** **How will their previous experiences of managing LBP without imaging influence their ability to deliver the intervention as intended?** • Rewards (proximal/distal, valued/not • valued, probable/improbable) • Incentives • Punishment • Consequents • Reinforcement • Contingencies • Sanctions	Q: If there was an incentive, it might be better? A: Yeah, it is.	Being rewarded acts as a facilitator to training and delivery.

Intentions	A conscious decision to perform a behaviour or a resolve to act in a certain way **Do they intend to/want to be trained in using the intervention?** **Do they intend to/want to deliver the intervention as intended?** • Stability of intentions • Stages of change model • Transtheoretical model and stages of change	I think that any type of booster session when you're participating in something is good, you know, it keeps you accountable. And just in case you're not exactly following protocols as set forth by the research study, then at least it can make sure that you're participating as you had committed originally.	Participant wants to deliver the intervention as intended.
Goals	Mental representations of outcomes or end states that an individual wants to achieve **Is being trained in using the intervention and managing LBP without imaging an important goal?** **How much of a priority is their training in using the intervention compared to other competing demands?** **Is delivering the intervention as intended and managing LBP without imaging an important goal?** **How much of a priority is delivering the intervention as intended compared to other competing demands?**	Q: Do you think non-indicated imaging for LBP is an important issue that needs to be addressed? A: Very much. Q: How important is it for you to deliver the intervention as planned? A: Very important.	Participant thinks that imaging is an important issue. This can imply a good fit between the provider and the intervention. Participant thinks it is important to deliver the intervention as planned.

	• Goals (distal/proximal) • Goal priority • Goal/target setting • Goals (autonomous/controlled) • Action planning • Implementation intention		
Memory, attention and decision processes	The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives **Will there be situations where they are likely to forget how they have been trained in using the intervention?** **Will there be situations where they are likely to forget to deliver the intervention as intended?** **Will there be situations where they decide not to deliver the intervention as intended?** • Memory • Attention • Attention control • Decision making • Cognitive overload/tiredness	Would it be allowed if I had a patient come in and I just didn't have time, so I skipped them?	Participant identifies a situation when they would not deliver the intervention as intended (when there is not enough time).
Environmental context and resources	Any circumstance of a person's situation or environment that discourages or encourages the	If I have them on a handout, it's something that they're receiving.	Participant regularly uses handouts to help deliver information. This can imply

	development of skills and abilities, independence, social competence and adaptive behaviour **What resources do they currently have that will allow them to be trained in using the intervention?** **What resources do they currently have that will allow them to deliver the intervention as intended?** • Environmental stressors • Resources/material resources • Organisational culture/climate • Salient events/critical incidents • Person × environment interaction • Barriers and facilitators	From a time perspective, that's always the hardest thing in practice. I think you'll probably get some resistance with respect to how long it would take for an appointment. Q: What challenges might you see with respect to being able to attend the session? A: I think for most, it would just be time. I would just have to schedule it in just like anything else.	that this practice will help them deliver the intervention as intended. Participant identifies time as a barrier to delivering the intervention as intended. Participant identifies time as a barrier to attending training for the intervention.
Social influences	Those interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviours **Are they influenced by other people (e.g., patients, colleagues) to be trained in using the intervention?** **Are they influenced by other people (e.g., patients, colleagues) to deliver the intervention as intended?**	Q: What impact do you think an intervention like this will have on your patients? A: Once they realise their education is in their best interest and not just because we can't give it [imaging] to you, I think it's very reasonable and I think people would be very receptive to it.	Participant thinks patients would be receptive. This could imply that they are more likely to deliver the intervention as intended.

	• Social pressure • Social norms • Group conformity • Social comparisons • Group norms • Social support • Power • Intergroup conflict • Alienation • Group identity • Modelling	Q: For patients who really want to have imaging, do you think that would impact your ability to deliver this intervention? A: No, I think it would be something to contend with, but I don't think it would prevent me from doing it.	Participant delivering the intervention as intended not influenced by patient requests for imaging.
Emotion	A complex reaction pattern, involving experiential, behavioural, and physiological elements, by which the individual attempts to deal with a personally significant matter or event **How do they feel about being trained in using the intervention and how do those feelings influence what they do (e.g., attending training)?** **How do they feel about delivering the intervention as intended and how do those feelings influence what they do?** • Fear • Anxiety • Affect • Stress • Depression	I would probably opt for role playing nonetheless even though I'm not comfortable with it. I think it [a script] would provide more comfort. I think instead of being seen as a time consumer, I think I'd feel that at least I was being thorough and that I wasn't missing anything. I think that would be very comforting to know that you're not missing anything.	Participant doesn't feel comfortable with role play for training (barrier), but would still do it (enabler). Participant feels comforted by having a script to help deliver the intervention as planned.

	• Positive/negative affect • Burn-out		
Behavioural regulation	Anything aimed at managing or changing objectively observed or measured actions **What existing strategies do they have to support them in getting trained in using the intervention?** **What additional strategies do they think would be helpful in getting trained in using the intervention?** **What existing strategies do they have to support them in delivering the intervention as intended?** **What additional strategies do they think would be helpful for them to deliver the intervention as intended?** • Self-monitoring • Breaking habit • Action planning	I think if you attach CE hours to it [training], people will participate. Q: What are some key things you would need to be in the training manual? A: Algorithmic charts and visuals. Digital format because you can click on a link and it's just tidy or you won't lose it. I think if the script could be honed enough that it would be all done in 15-20 minutes. It would be about fitting it into an appointment time.	Participant thinks CE credits would support getting clinicians trained in using the intervention. Strategies to improve training in using the intervention. Strategies to improve delivery of the intervention as planned.
Other codes (for inductive analysis)	Statements that do not directly relate to a domain but are relevant to the development of the intervention		

Appendix 9 Ethics approval

Research Ethics Office
Suite 200, Eastern Trust Building
95 Bonaventure Avenue
St. John's, NL
A1B 2X5

December 17, 2020

Health Science Centre Rm 5315
300 Prince Philip Drive
St. John's, NL A1B 3V6

Dear Ms. To:

Researcher Portal File # 20211145
Reference # 2020.299

RE: A qualitative study of strategies to enhance intervention fidelity of a multi-component intervention to reduce non-indicated imaging for low back pain

Your application was reviewed by a subcommittee under the direction of the HREB and the following decision was rendered:

X	Approval
	Approval subject to changes
	Rejection

Ethics approval is granted for one year effective December 17, 2020. This ethics approval will be reported to the board at the next scheduled HREB meeting.

This is to confirm that the HREB reviewed and approved or acknowledged the following documents (as indicated):

- Project Information Sheet 2020/12/16 approved
- Website Invitation 2020/12/10 approved
- GP Recruitment Email 2020/12/10 approved
- Chiropractor Recruitment Email 2020/12/10 approved
- Proposal, approved
- Budget, acknowledged

Please note the following:

- This ethics approval will lapse on December 17, 2021. It is your responsibility to ensure that the Ethics Renewal form is submitted prior to the renewal date.
- This is your ethics approval only. Organizational approval may also be required. It is your responsibility to seek the necessary organizational approvals.
- Modifications of the study are not permitted without prior approval from the HREB. Request for modification to the study must be outlined on the relevant Event Form available on the Researcher Portal website.
- Though this research has received HREB approval, you are responsible for the ethical conduct of this research.
- If you have any questions please contact info@hrea.ca or 709 777 6974.

The HREB operates according to the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS2), ICH Guidance E6: Good Clinical Practice Guidelines (GCP), the Health Research Ethics Authority Act (HREA Act) and applicable laws and regulations.

We wish you every success with your study.

Sincerely,

Health Research Ethics Board